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MULTIPURPOSE MODIFICATION OF PLAYA SINKS

Lubbock City-County Health Unit

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First Annual Progress Report

Lubbock, Texas
December 31, 1962

Multipurpose Modification
OF
PLAYA SINKS

PROJECT NUMBER 29 DIVISION OF WATER SUPPLY AND POLUTION CONTROL

UNITED STATES PUBLIC HEALTH SERVICE

PRESENTED BY

LUBBOCK CITY-COUNTY HEALTH UNIT
in cooperation with

HIGH PLAINS UNDERGROUND WATER CONSERVATION DISTRICT

TEXAS TECHNOLOGICAL COLLEGE

UNITED STATES PUBLIC HEALTH SERVICE

TEXAS STATE DEPARTMENT OF HEALTH

TEXAS WATER COMMISSION

ACKNOWLEDGMENTS

A project of such wide significance to the public health of a major locality draws the support and cooperation of many agencies and individuals.

Mr. Walter Breedlove, Cheif Public Health Engineer of the Lubbock City-County Health Unit has for years fostered and sponsored the development of the research problems represented in this project. His efforts in securing and organizing the project, his keen interest in, and excellent advise and technical support of this study are especially appreciated.

Dr. A. D. Hess and colleague J. V. Smith and Bruce Francy of the USPHS, Greely, Colorado, have been most helpful in planning the program, resolving technical problems and securing equipment.

Dr. J. V. Irons, Director of the Laboratory and Frank J. Vonzuben, Jr. of the Texas State Health Department and colleagues have conducted certain water and chemical analyses involved in the biological phases of the project.

Don Krieble and M. G. Sheldon, United States Fish and Wildlife Service have assisted in cataloging and identifying vertebrate species; Professor Chester Rowell of the Biology Department, Texas Technological College, has certified or identified specimens of the higher plants collected in the study.

Allan H. White, Jr. High Plains Underground Water Conservation District, and Jack B. Pearce, Texas Technological College have been most cooperative in arranging photography and publicity for the project.

The Texas Water Commission has supplied the water level recorders used on the project.

The following have also helped as advisors and consultants:

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Dr. Donald Ashdown, Texas Technological College
James C. Willman, Assistant Engineer Region 1 Supervisor, State Health Dept.
Mr. Al Couch of City of Lubbock, Director of Finance
Frank J. Vonzuben, Jr., Chief Engineer Environmental Dept. Program, State Health Dept.
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INTRODUCTION

The High Plains of Texas consists of approximatley 35,000 square miles or 22,000,000 acres, with only about 10 percent of the plains being within the drainage basin of the Canadian, Red, Brazos, and Colorado Rivers. The remaining 90 percent of the area contributes surface runoff into the thousands of playa depressions throughout the plains.

The climate of the High Plains is semi-arid; the annual precipitation averages about 20 inches. Approximately 70 percent of the rain falls during the growing season from April through September.

The origin of the plays depressions has been suggested as having been the result of three primary factors. Owing to the heterogeneous nature of the High Plains deposits, which are alluvial outwashes from the mountains to the west, differential settling occurred. As a result of the differential settling and the generally level surface, runoff collected in the low areas and percolated downward removing the soluble and colloidal materials. The depressions which resulted were further enlarged and deepened by wind erosion due to lack of soil-holding vegetation which could not thrive in the presence of standing water.

The playa depressions show great variability in size and depth, ranging from a few feet to a mile in diameter, and from a few inches to 50 feet in depth. The water-holding characteristics of the playa vary according to the soil. Many of the depressions contain thick layers of clay and colloidal material which, when wet, become relatively impermeable and impede natural recharge of the underlying aquifer. Data collected by the U.S. Geological Survey and the Texas Water Commission show that approximately 90 percent of the water collected in the playa depressions or lakes goes back into the air through evaporation and transpiration.

A study of 1,348 lakes in four counties indicated that in 1957, an above normal year for precipitation, runoff amounted to nearly 200,000 acre-feet. In 1958, a below normal year, the lakes collected approximately 37,000 acre feet of water.

It was estimated in 1958 that 160,000,000 acre-feet of water remained in the Ogallala underground reservoir of the Southern High Plains. Withdrawal of 3,000,000 to 5,000,000 acre-feet of water per year by about 44,000 wells which irrigate approximately 4,300,000 acres of land is seriously depleting the water supply.

Through erosion, the Ogallala formation has been isolated from any water-bearing beds outside the area, except underlying older rocks which contain highly-mineralized water. As a result, the source of all the water entering the Ogallala formation is precipitation which falls on the plains of Texas and New Mexico.

With the economy of the area dependent upon irrigated agriculture, it is imperative that all methods of water conservation be studied and put into practice when possible.

In addition to water lost to the economy of the area; when flooded, the playa lakes represent hundreds of acres of valuable land lost for an economic return. With the cost of irrigated land ranging up to $1,000000 per acre, recovery of as much of this land as possible would seem very desirable. Although additional land for farming may not seem necessary in light of the present surpluses, with the world population expanding at the rate of 140,000 people per day, it seems feasible to assume that the surplus problem will be one of a temporary nature, and that the real problem may eventually be one of finding enough tillable land to feed the people.

It has been well established, through studies by the U.S. Public Health Service and the Texas State Health Department, that playa lakes form the major habitat for the vector of arbor encephalitis in Western Texas. In a study by the Encephalitis section of the U.S.P.H.S. in 1954, playa lakes in the study area accounted for approximately 75 percent of the mosquito production. During the seven-year period of 1954-60 in eleven counties in Northwest Texas, 460 cases of infectious encelhalitis were reported to the Texas State Health Department. In 1955, an epidemic of mixed WE ans SL encephalitis occurred in Northwest Texas. Attack rates ranged from 1 to 1,000 up to 2 per 1,000 population in some counties.

The history of the endemicity of encephalitis viruses extends back for many years from the reports of equine encephalitis. Recent work, started in 1958 in Hale and Lubbock Counties by the Encephalitis Section, U.S.P.H.S. and continuing through the present, show a very high degree of virus activity in these areas. Numerous isolations of Western and St. Louis virus have been made from the collections of Culex tarsalis and Culex quinquefasciatus by the Texas State Health Department, the Encephalitis Section, CDC, and the National Biological Institute, Hamilton, Montana.

That the vectors are abundant is shown by repeated collections of up to 4,000 mosquitoes in a light trap in a single night in the area around Hale Center in Hale county. With the high degree of virus activity and the abundance of the vectors, the possibility of outbreaks of epidemic proportions is always present.

With the increased urbanization of many areas of the plains, the problems of pest of floodwater mosquitoes also become increasingly important. In the case of the City of Lubbock, urbanization has spread to the point that a good portion of the residential areas is in close proximity to playa lakes, thus exposing large numbers of people to the mosquitoes produced in these areas. With the extremely high levels of relief from mosquito annoyance enjoyed in many other areas of the country, the Lubbock city residents will increasingly demand more efficient control of mosquitoes.

Playa lakes of the Texas High Plains form an integral part of the flight lanes for waterfowl moving to and from the Texas Gulf Coast. In those years with higher than normal precipitation, the many playas help overwinter large numbers of waterfowl. In addition to the importance of these lakes to waterfowl, the development of fisheries in the plains area may result from more efficient use of these playa lakes or depressions.

With the great potential benefit to all facets of the population and economy of the area, methods are being developed and field tested for multipurpose modification of playa depressions which will best adapt them for disposal of sewage effluent, prevention of mosquito production, soil and water conservation and wildlife use.

The results of the first year of observation and studies are presented in this report along with proposed procedures for the coming year.

PART I

BIOLOGY AND ECOLOGY OF PLAYA LAKES

Conducted and written by Dr. Ellis W. Huddleston

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Entomology Section, Department of Horticulture and Park Management

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BIOLOGICAL PHASES OF THE PLAYA LAKE STUDY

Introduction

Playa lakes have long functioned as primary environments in mosquito breeding. The biological aspects and characteristics of the natural playa sink may well hold the key to the kind of design best suited in the modification phases of this study. To give definition to the values derived in the biological studies, major efforts have been spent to achieve statistically sound data in the mosquito production indices. Certain lakes are under intensive investigation for all phases of the study, while others are sampled occasionally for other phases but equally intensively for mosquito larval production.

Other facets of the problem which have been or will be investigated are the changes and variations in water chemistry with particular emphasis on those chemical components most likely to affect mosquito production and fish production. Techniques for estimating overwintering mosquito egg numbers are being studied and modified to adapt to local water and soil conditions. Laboratory procedures for the culture of two local species of mosquitoes, (Culex tarsalis and Culiseta inornata) are being developed. Several new light trap designs are being evaluated and compared to find one best suited in collecting the major species of the area. "Mark-Recapture" techniques are to be developed and tested to explore adult migration patterns. Other areas in the biology of the playas which are being studied include survey and identification of invertebrates other than mosquitoes, wildlife, and vegetation species. Phytoplankton and zooplankton are being studied from both qualative and quantative aspects.

A BRIEF SYNOPOSIS OF THE CURRENT SEASON

The 1962 season has been one inducing biological extremes in the playa enviroment. The fall, winter and early spring were exceptionally dry, and no lake under study had any impounded water prior to April 11, 1962. During the windy months of March and April these lakes were "dust bowls"; normally, April and May rainfall is sufficient to induce a spring hatch of mosquitoes. The drought was terminated by local and erratic May showers which impounded sufficient water in a few lakes to produce batches of mosquitoes. Perennial weeds grew abundantly in the shore area of most lakes, even during the drought period. These conditions delayed and limited early studies of the aquatic characteristics in the playa areas. Above normal precipitation in July produced above normal runoff and impounding in the playas, with major production of many species of plant life, wildlife, mosquitoes, and other vertebrates. A condition of essentially no rainfall in August allowed several of the study lakes to go dry prior to heavy recharging rain periods in late August and early September. Such weather patterns have been known previously, but are hardly typical insofar as mosquito breeding is concerned.

MOSQUITO STUDIES

Mosquito studies include those on production of larvae, light trap records of adult forms, egg survey and laboratory culture of key species.

LARVAL PRODUCTION STUDIES AND TECHNIQUES

Major emphasis during the past season has been on larval productions with particular respect to species-time relationships. Both numbers of individual species, and species composition have been studied. It must be remembered that playa lakes form a generic series of biological habitats, with extreme variation in size, shape and other components of the environment.

Since the study lakes vary in size from 10 to 30 acres of impoundment area, complete dip-sampling for mosquito breeding was found to be impossible. In order to achieve representative values in study lakes the transect method for location of dipping stations was used. A stake located in the center of the one-foot contour line area was used as the sampling index point. Transect lines at 36 degree intervals were established and marked with painted laths driven into the soil beyond the shore line. Since some of these were 600 to 700 feet distant from the center post, it was found desirable to paint the entire lath with a white base coat, then add a coat of luminous orange paint (Day Glow) of the type used in jet aircraft marking. These were found satisfactory and discernable even under dawn and twilight visability conditions.

Individual dipping stations were located at thirty-foot intervals, starting at the shore line and proceeding toward the center stake. At each sampling station one to three dippings were made with a white enamel dipper of approximately one pint capacity. Upon arriving on station, the sampler, clad in either hip boots or chest-high waders, paused for a period to minimize stirring of the water and disturbance of larvae. During this pause the sampler filled in the pertinent items of data on the dipping report form (Appendix III). Water depth, total per cent of water surface covered by plants, per cent broadleafed weeds, and per cent grass were recorded.

One to three dippings were then made, and the mosquito larve examined and recorded as to total number and number in each instar. Fourth instar specimens were retained and returned to the laboratory for determination of species composition; the percent Culex tarsalis is presented in Appendix IV. Appendix IV also presents the mean numbers of mosquito larvae found in each lake on each sampling date through August 30 (figures 1-10b). For dipping dates following July 25 the dipping figures have been adjusted to compensate for differing areas represented by each counting station. The dipping data prior to this time was not complete enough to allow index calculations by contour, and are therefore presented on a separate chart as the arithmetic averages for all dips made. The indices presented in Appendix IV were evolved from the formula:

Average number of larvae / dip/ contour X surface acres of water per countour.

Since all of the study lakes have been mapped on one foot contour lines, the area represented by each station has been calculated (Appendix I). Additional information will be secured to determine dipping efficiency indices. As there is an apparent correlation between water depth, vegetative cover, and mosquito larvae numbers, correlation and regression analysis will be made from the data already derived from the study.

The average numbers of larvae per dip varied from zero to 6.0; the indices for total number of larvae varied from zero to 120.03; the fourth instar indices varied from zero to 35.98. In presenting these data separate graphs have been made showing the indices or larval count-date relationship's at the top with surface acres of water and rainfall below. These values are simultaneously presented to help establish and interpret interrelationships of rainfall pattern and inundation of the lake bed on overwintering egg hatch and Culicine egg deposition.

One item of particular importance is the effect of water level at the previous season upon larval populations following the filling of the lake basin during the current season. In those cases where water level was high during the oviposition period the previous season, small rains would not be expected to inundate and cause hatching of eggs in the current season.

A visual interpretation of the data shows that the drought period of May, June and early July produced sub-normal mosquito numbers in all lakes. The pattern of isolated rain showers can be seen in the rainfall graph and the production graph. Initial production dates were extremely varied for the ten lakes ranging from April 11 to July 23 for nine of the lakes; Huckabee lake has not impounded water and therefore has not produced mosquito larvae to date. Most lakes began produving mosquitoes following heavy rainfall about mid July. Production was almost as variable as the time of initial hatch.

In evaluation of these data several factors must be taken in consideration. First, dates plotted are actual dipping dates which may be up to a week apart for a particular lake. Due to the time span; the peaks may be considered only as a crude approximation; since, at one sampling date, a large percentage of the larvae found may be fourth instars, while only a few or no first instar larvae were found the previous sampling date. Thus, allowing for normal mortality, one can see that a much higher peak was reached between sampling dates.

Second, the numbers in figures 1-10a, while of approximately the same order of magnitude, are only an index figure, since they have not been corrected for areas sampled. The bias enters, since all transects center on the mid-point of the lake, causing many dipping stations to be in the center of the lake in what is often deep, open water, not conducive to large numbers of mosquito larvae. The larval indices presented in figures 1-10b and have been corrected and reduce bias.

Third, these figures represent a complete sampling of a ten acre or larger area, and not a biased sample from the most productive areas, as is frequently taken for control recommendations. Since each sampling date may represent up to 200 dipping stations with many zero counts, maximums of 300 to 400 per dip are lost in the average.

A summary of the data presented in the graphs and charts in Appendix IV shows the average time water was impounded in these ten lakes during the period from July 24 to November 30 was 98.8 days. The maximum length of time water was held by one of these lakes was 170 days for Kitten's Lake. Lake I, Huckabee, had no impounded water

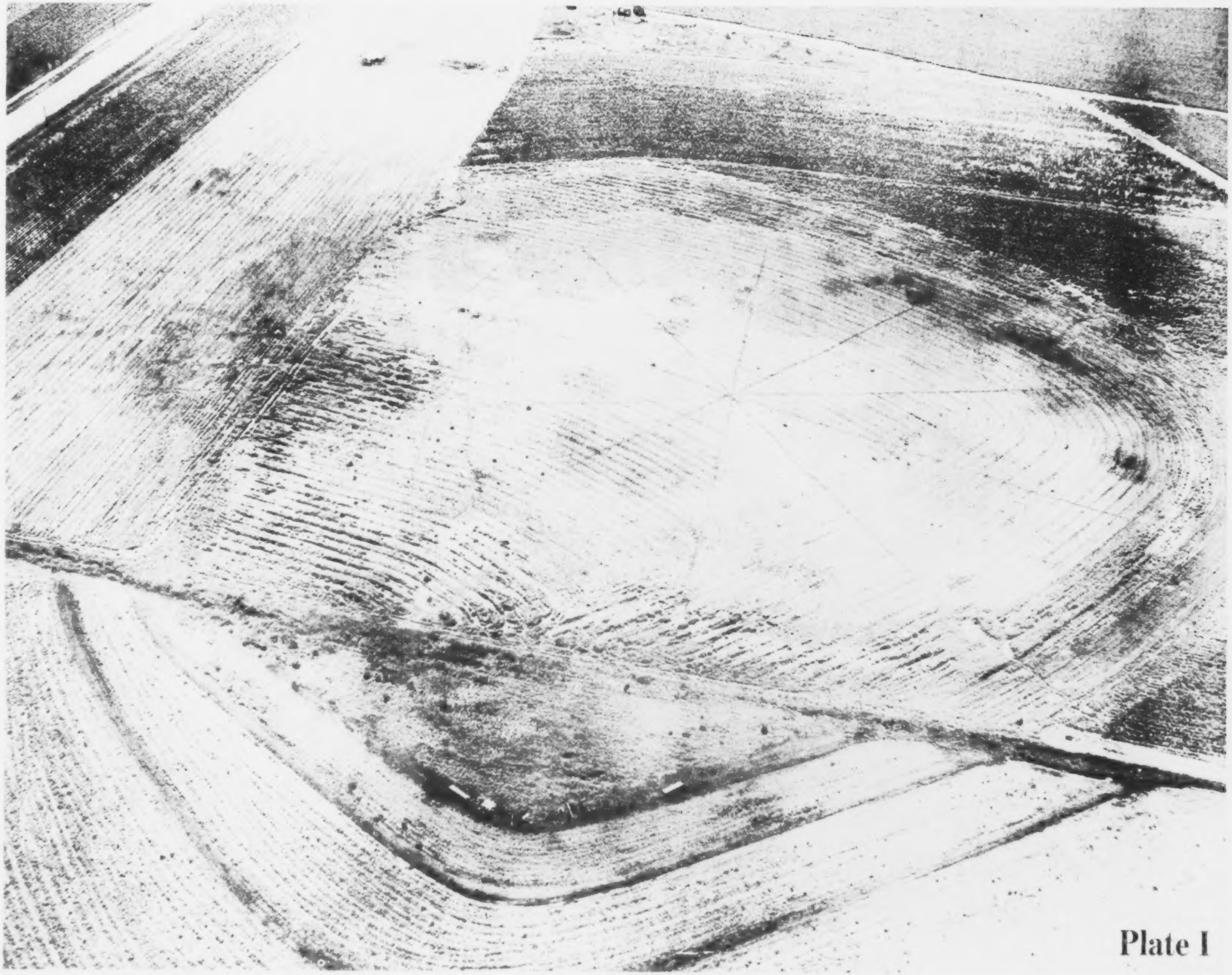


Plate I

for the entire period and represents the minimum. The average acreage covered by water for the ten lakes was 6.58 acres. This varied from a maximum average of 17.8 acres for Kitten's lake to zero for Huckabee's lake. Cooper's lake had 3.84 feet of impounded water at one time during the period and represents the deepest lake in the study. The average index for fourth instar larvae for the ten lakes was 1.57 and the average total instar index was 9.55 per dipping date. Cooper's lake had the maximum fourth instar index average per dipping date of 4.67 and the maximum total instar index average was 28.11 at Kitten's lake. The highest single figures for one dipping date was 120.03 for total number of all larvae index and 35.98 for the fourth instar index. Huckabee again had the minimum with no mosquito production.

With these data, a preliminary conclusion as to control recommendations would indicate that pre-flood treatments with insecticides would be subject to many limitations. Important among these are the erratic rainfall patterns which imply that on some lakes chemicals would be exposed to heat, sunlight, showers, and wind action for periods of two to three months prior to flooding. In others, vegetative growth would tend to dissipate and tie up residues. Research on different granular formulations should be attempted in the next season.

EGG SURVEY

Only preliminary egg survey studies have been conducted to the present. A great deal of difficulty was experienced in separating eggs from the considerable amounts of organic debris and colloidal inorganic sediments.

It is hoped that techniques for egg sampling can be developed to the extent that studies of egg location in reference to shore line at oviposition time can be conducted. These studies will be made during the coming winter.

Two types of equipment for separation of mosquito eggs from the soil have been obtained. The Horsefall equipment and that of the Public Health Service will be employed. In preparation for these studies, shore lines are now being staked at each larval sampling date. This information together with staff gage readings and light trap collection of adults will be used to predict zones of egg deposition on the lakes. A statistically sound egg sampling procedure will be developed to facilitate evaluation of the techniques employed in predicting egg deposition zones.

Development of a technique for prediction of the finite band of egg deposition offers the possibility for research on the use of ovicidal and other toxicants for spot treatment to control pest mosquitoes. By limiting the area requiring treatment great economies could be achieved. This type of approach becomes especially important in planning for the establishment of a mosquito abatement district in this area.

LIGHT TRAP RECORDS

Species composition of adult mosquitoes taken in light traps have been analyzed and recorded for several years by personnel of the City-County Health Unit. These data provide an information base line to predict peaks of mosquito production from playa lakes.

Figure I shows mosquito production and that of Culex tarsalis for the past two years.

The lack, until September, of suitable electric power sources at the lake sites has precluded operation of suitable and adequate traps; weekly trapping records will be initiated the coming season.

Light trap designs to be employed in the tests are as follows:

1. The Standard New Jersey Trap.
2. An ultraviolet-multidirectional trap without fan supplied by USDA, Plant Pest Control.
3. Agricultural Model of "Lura Light", a multidirectional trap employing four circular ultraviolet emitting tubes mounted on a cylindrical fan housing.
4. Home Model of "Lura Light", an undidirectional ultraviolet emitting trap with fan.

As power sources are now available at the study lake sites, these traps will be operated next season.

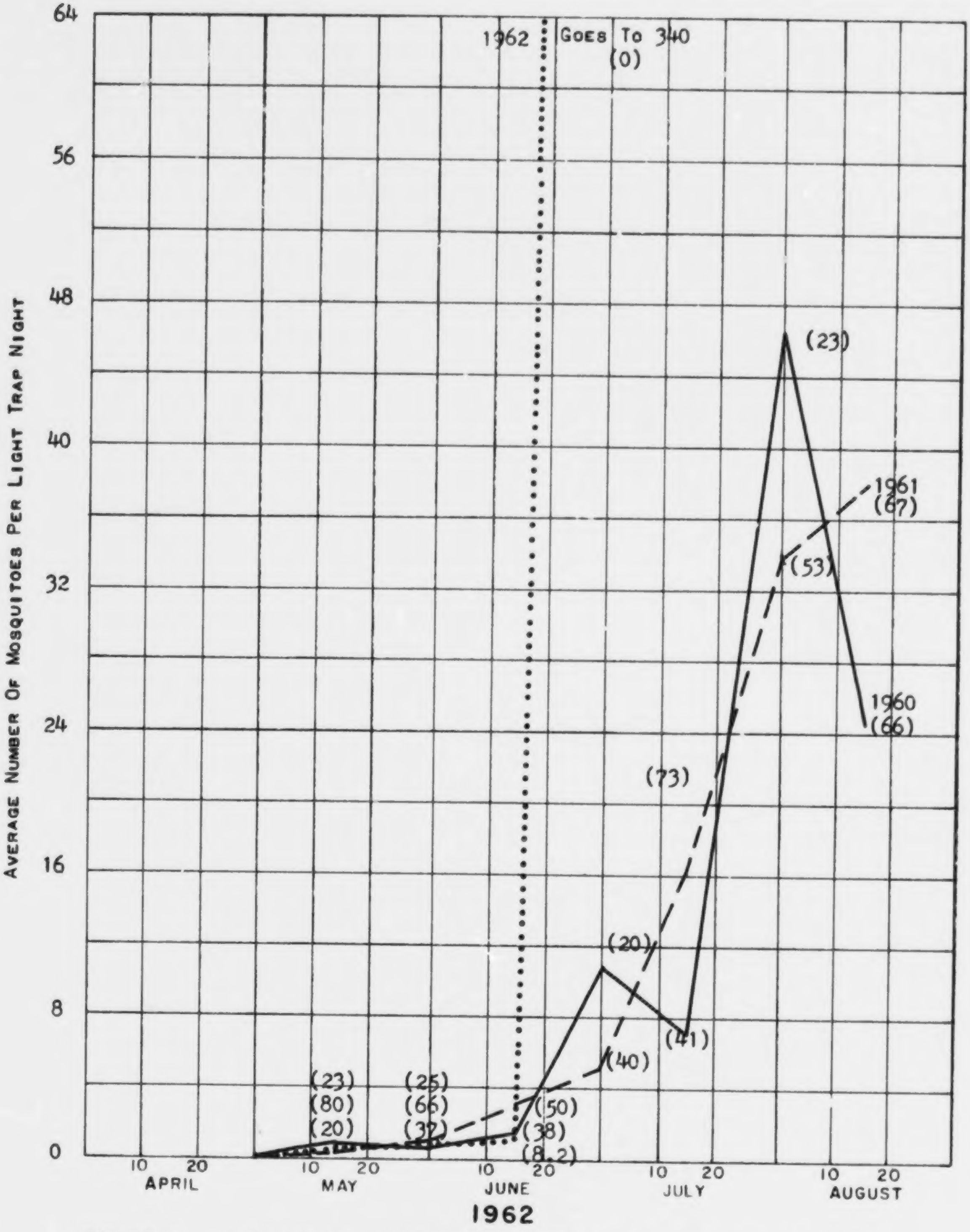


FIGURE 1. AVERAGE NO. OF MOSQUITOES PER LIGHT TRAP NIGHT FOR TRAPS LOCATED WITHIN THE CITY OF LUBBOCK. FIGURES IN ( ) INDICATE % OF TOTAL CATCH THAT WAS *Culex tarsalis*. 1960-1962.

Date	Total Number of Mosquitoes per Light Trap Night	Number of *Culex* tarsalis per Light Trap Night	Percent of *Culex* tarsalis per Light Trap Night
7-3	350	-	-
7-9	92	1	1
7-16	34	3	9
7-23	164	33	20
7-30	96	45	47
8-6	1350	53	4
8-13	1330	330	25
8-20	374	250	67
8-27	248	220	89
9-4	124	100	81
9-11	166	144	90
9-19	820	45	5
9-26	316	40	13
10-2	114	30	26
10-8	148	29	20
10-15	252	6	2
10-22	126	11	9
10-29	54	17	31
11-6	56	3.4	5
11-12	32	1.3	4
11-19	37	1	3
11-26	81	5	6
12-3	40	0	0
12-10	5	0	0

Figure 1. (Contd) AVERAGE NO. OF MOSQUITOES PER LIGHT TRAP NIGHT FOR TRAPS LOCATED WITHIN THE CITY OF LUBBOCK.

LABORATORY CULTURES AND STUDIES

Culturing techniques described in the literature have been reviewed and evaluated in this laboratory so that cultures of Culiseta inornata and Culex tarsalis may be reared, and studied during the winter. Testing of the effect of variations in ecological factors upon development of strains obtained from the playa lakes will be conducted. A variable tempature cabinet with programmer for both tempature and photoperiod will be available for laboratory studies during the winter.

WATER CHEMISTRY STUDIES

Playa lakes present a number of unusual water chemistry characteristics when compared with running streams or deeper impounded bodies of water. Most lakes are located in highly calcareous soils, and are the end site reservoir of much surface run-off which might well carry native soluble salts. A considerable variation from lake to lake might well be expected, depending on water origin and resources feeding the catch basin.

Water chemistry studies, made in cooperation with the Texas State Department of Health are underway. These are designed to determine the chemical composition of the water of playas, to correlate such with mosquito production and to evaluate potential use of such waters for fish production following modification of the lake bed.

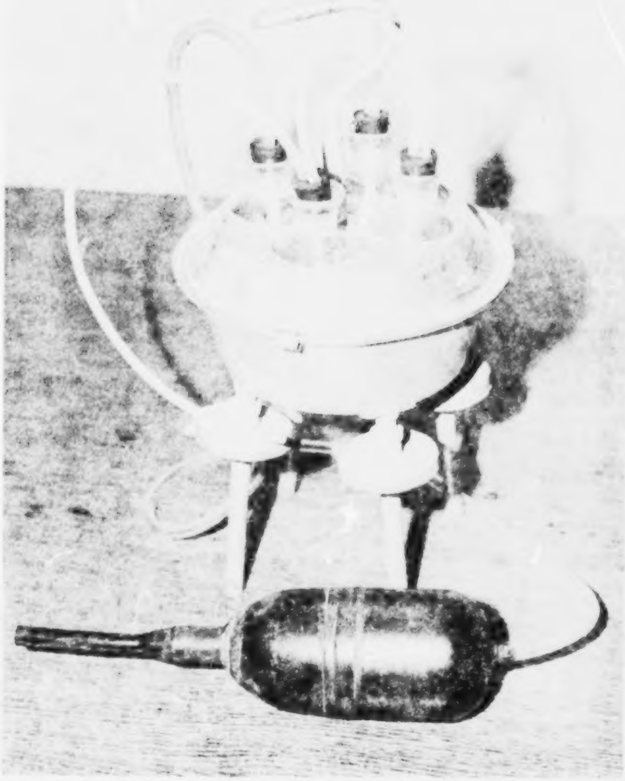
Work on the standard water analysis and detection of pesticidal residues in water is being conducted at Austin. Table I gives the preliminary chemical composition of water for representative playa sinks in this area. (Appendix V).

Work by our laboratory consists of tests made to determine content of dissolved ozygen, free carbon dioxide, total soluble salts, pH, and alkalinity. Average content, and range of dissolved oxygen, carbon dioxide content, and pH of the playa water as determined in local tests is presented in Tables II, III, and IV, (Appendix V).

A water sampler device for the project has been designed and built using the principal of an air displacement train. Four 300 ml. B.O.D. bottles, connected in series and housed within an aluminum tank, are used to collect the water samples. When sampling shallow water, a rubber air pump is used for air displacement, (Plate II).

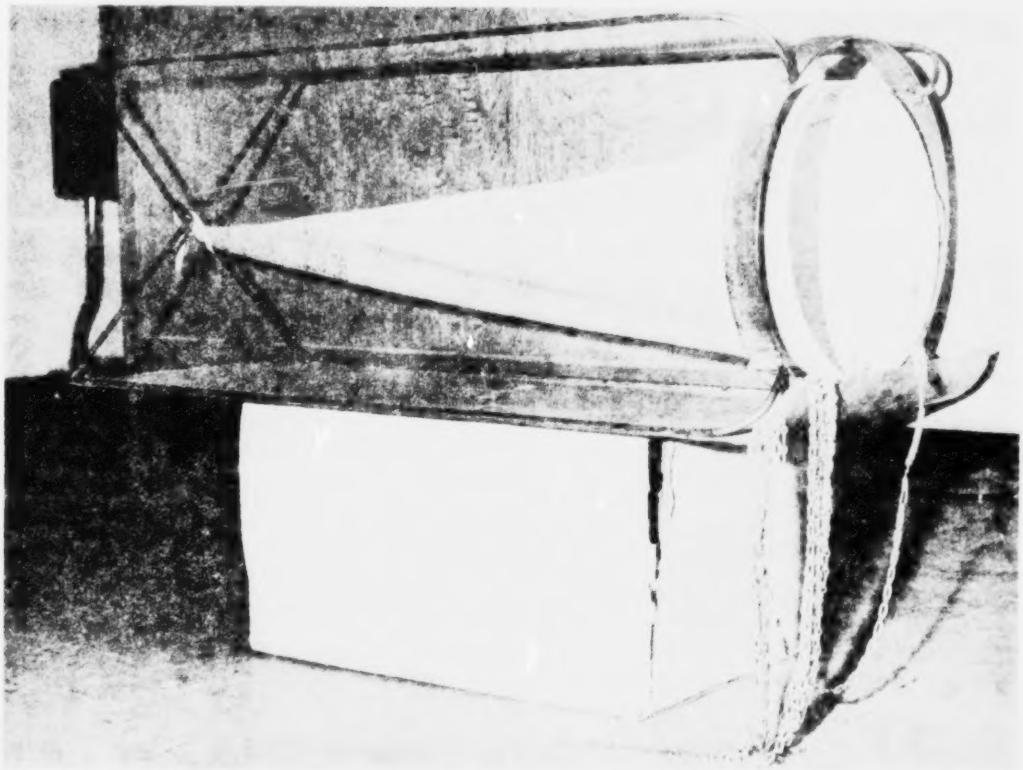
While great variation occurs, the inundated area would seem to present ecological zones. The shore line, while always present, varies from thick vegetative cover to bare mud. In many cases, the central portion of the lake is deep enough to be devoid of all emergent vegetation. The area between the open water of the center and the shore line is usually a zone of emergent floating vegetation.

Samples were collected in these three apparent ecological zones; shore line, weed zone and open water areas. An additional series of samples were taken over a 24 hour period. Preliminary evaluation of these dates seems to indicate that variation



WATER SAMPLER

WATER SAMPLER IN USE



PLANKTON NET

of dissolved oxygen is as great within a given lake studied during its diurnal cycle, as among different lakes sampled at a given time (Figure II). Free carbon dioxide was relatively high in the water soon after the lake was filled with rain recharge, but was rapidly dissipated to the zero level thereafter. The diurnal fluctuation in alkalinity, total solids and pH were studied (Figure III). These data indicate a negative correlation between dissolved oxygen and pH.

One of the features which best characterizes these data is its variability. To resolve some of these variations another experiment was designed to further investigate this problem. Samples were taken at thirty foot intervals from the shore line to the center of the lake (stops 1 to 8). Preliminary evaluation of the data in Table V (Appendix V) indicates that observations along a transect are no more variable than would be explained to the parameter of true population variation plus time of day and water tempature.

All analyses were conducted as outlined in Standard Methods for the Examination of Water and Waste Water. 11th Ed.

FLORAL AND VERTEBRATE IDENTIFICATION

Collections of the floral and vertebrate forms have been made during the past year and the specimens identified. Of the higher plants 40 species were found. Polygonum lapthifolium and Sagittaria longiloba were the dominant aquatic plants, and Vernonia baldwinii and Artemesia gnaphaloides the dominant achthophilalis plants found in the basin area of the lakes studied.

Animal studies indicated a total of 69 species of vetebrates. Of these 8 were Amphibia, 8 Reptillia, 48 Aves and 5 Mammalia (Appendix VI).

PLANKTON STUDIES

Plankton studies are being made with weekly samplings of the lakes. A modified Birge net of 125 mesh has been designed to operate in the turbid waters characteristically found in lakes, (Plate III). Each sample consists of material from a net drawn 20 feet at each of two sampling stations. Samples are preserved in a formalin-alcohol for counting and identification during the winter.

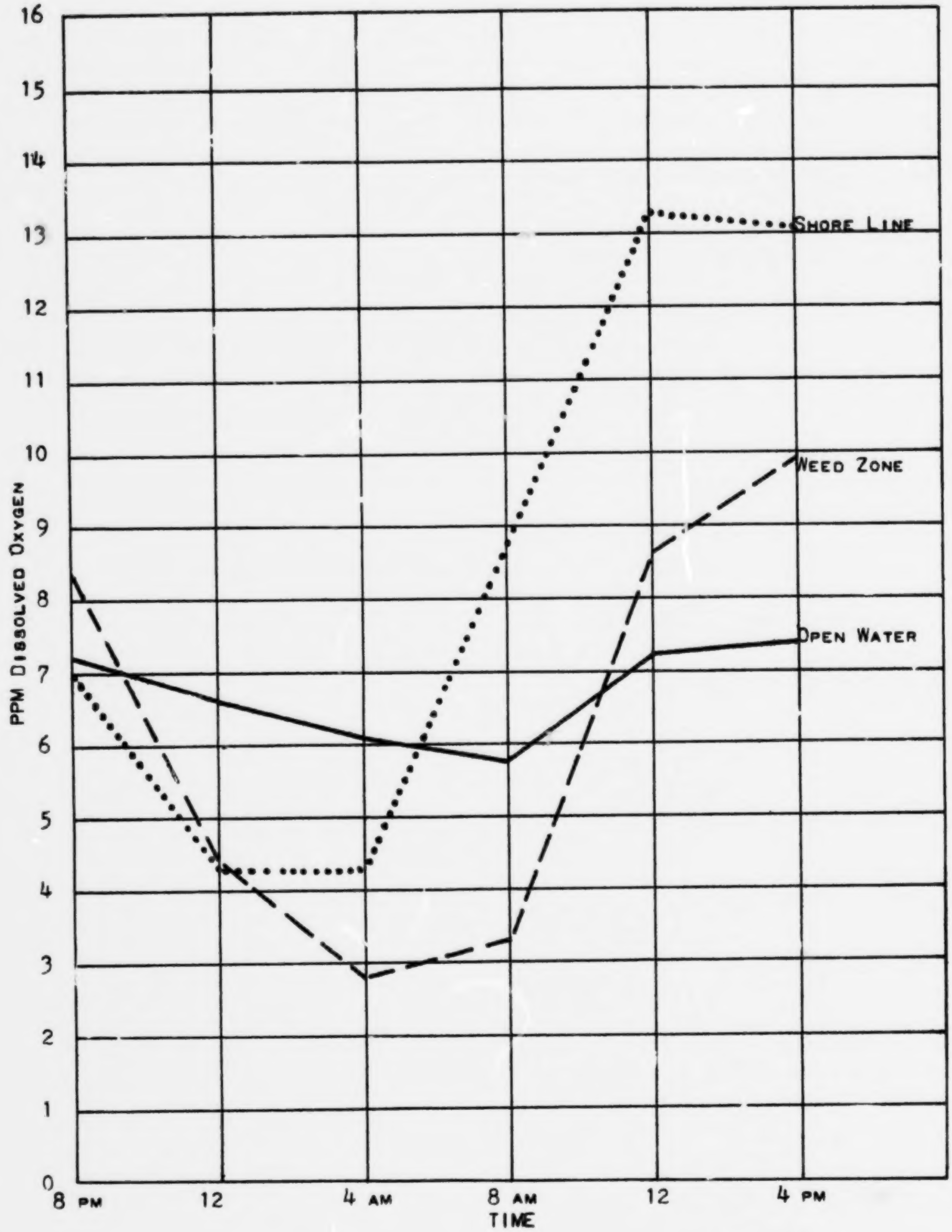


FIGURE 2. AVERAGE OF DUPLICATE ANALYSIS FOR DISSOLVED OXYGEN TAKEN EVERY FOUR HOURS FOR A 24 HOUR PERIOD. SAMPLES WERE TAKEN FROM THE SHORE LINE, ZONE OF WEED GROWTH AND OPEN WATER. AUGUST 17-18, 1962. LAKE 4. LUBBOCK, TEXAS.

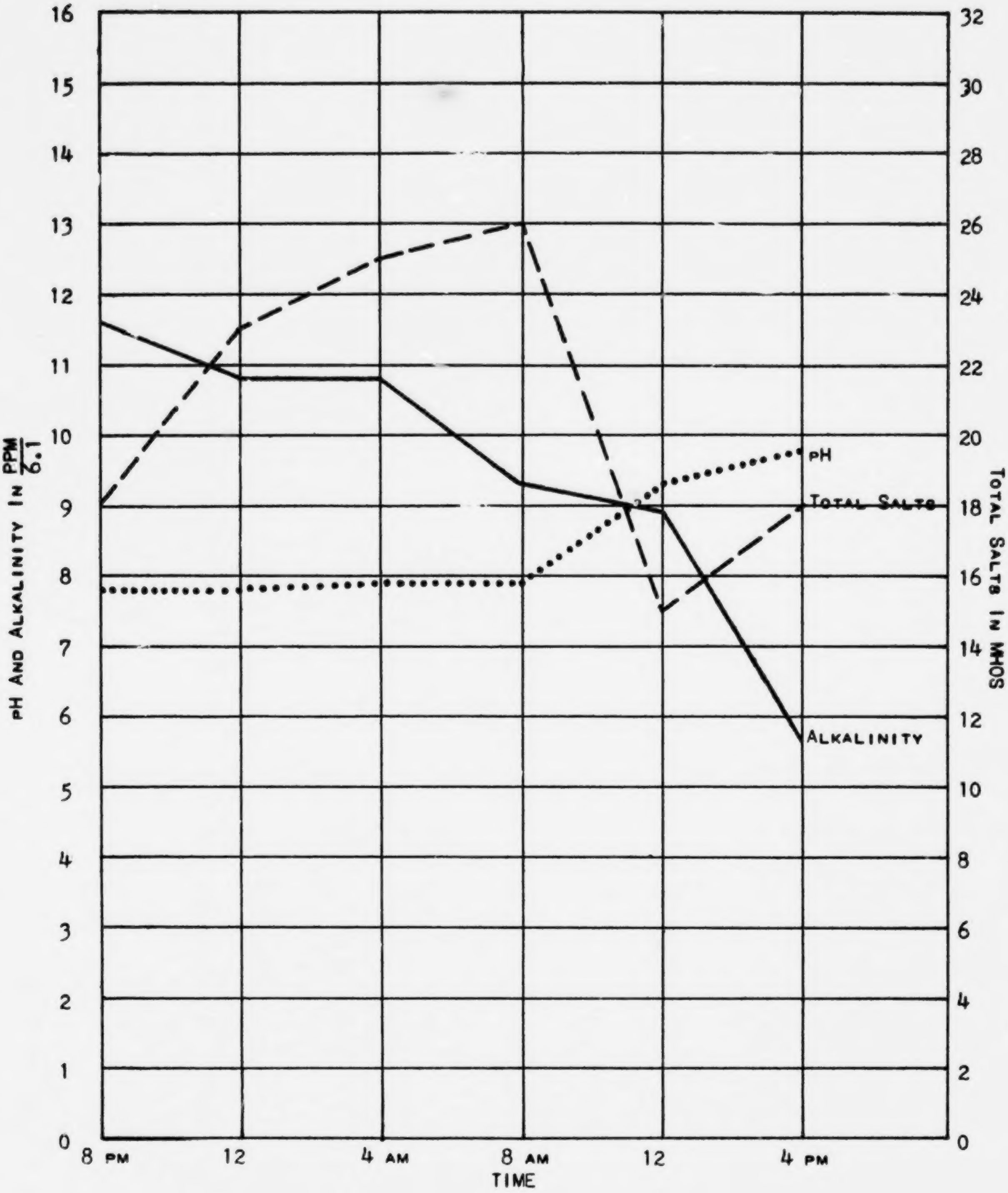


FIGURE 3. AVERAGES OF DUPLICATE ANALYSES FOR ALKALINITY, pH, AND TOTAL SALTS EVERY FOUR HOURS FOR A 24 HOUR PERIOD. ALKALINITY AND TOTAL SALTS REDUCED BY CONSTANTS FOR GRAPHIC REPRESENTATION. AUGUST 17-18, 1962. LAKE 4. LUBBOCK, TEXAS.

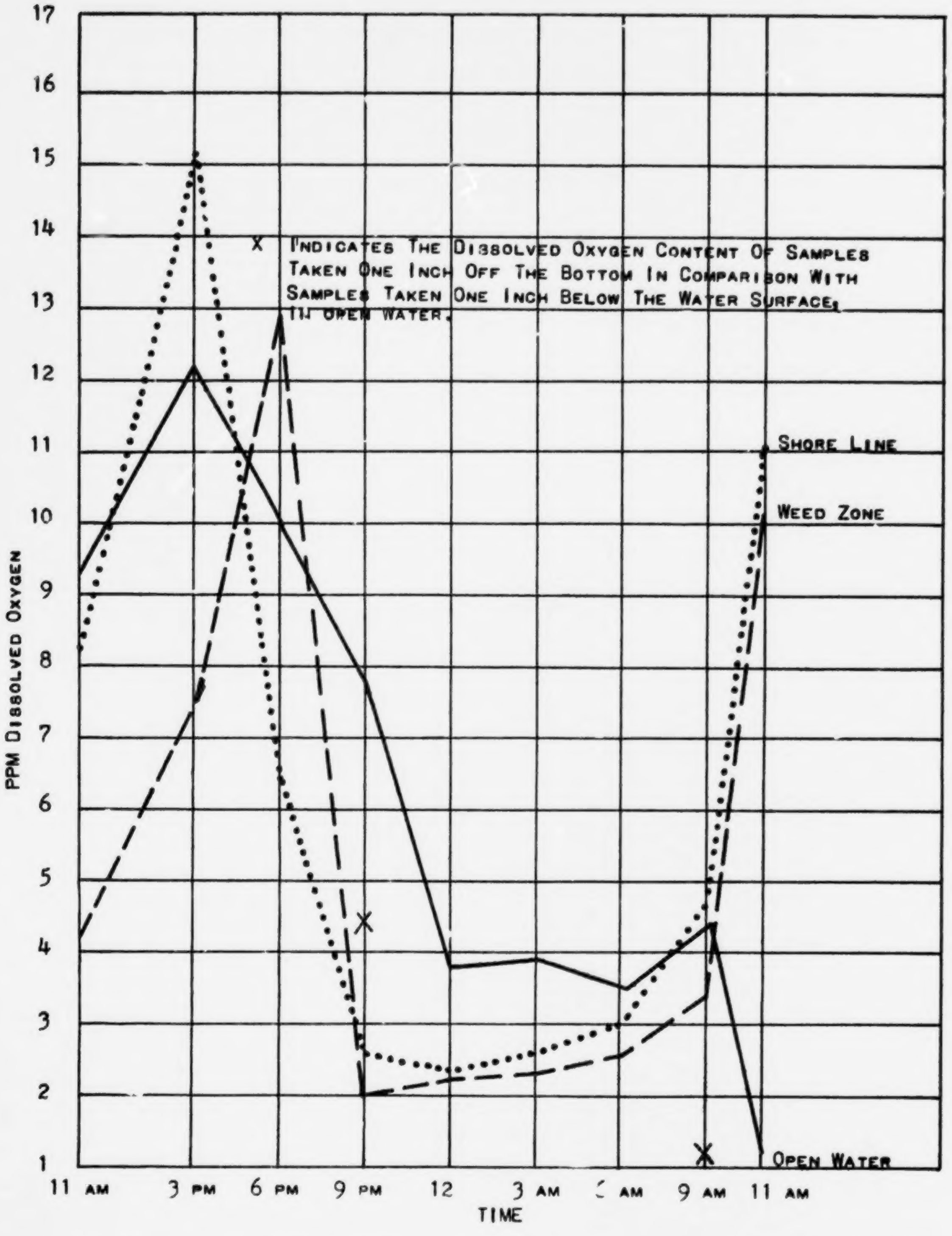
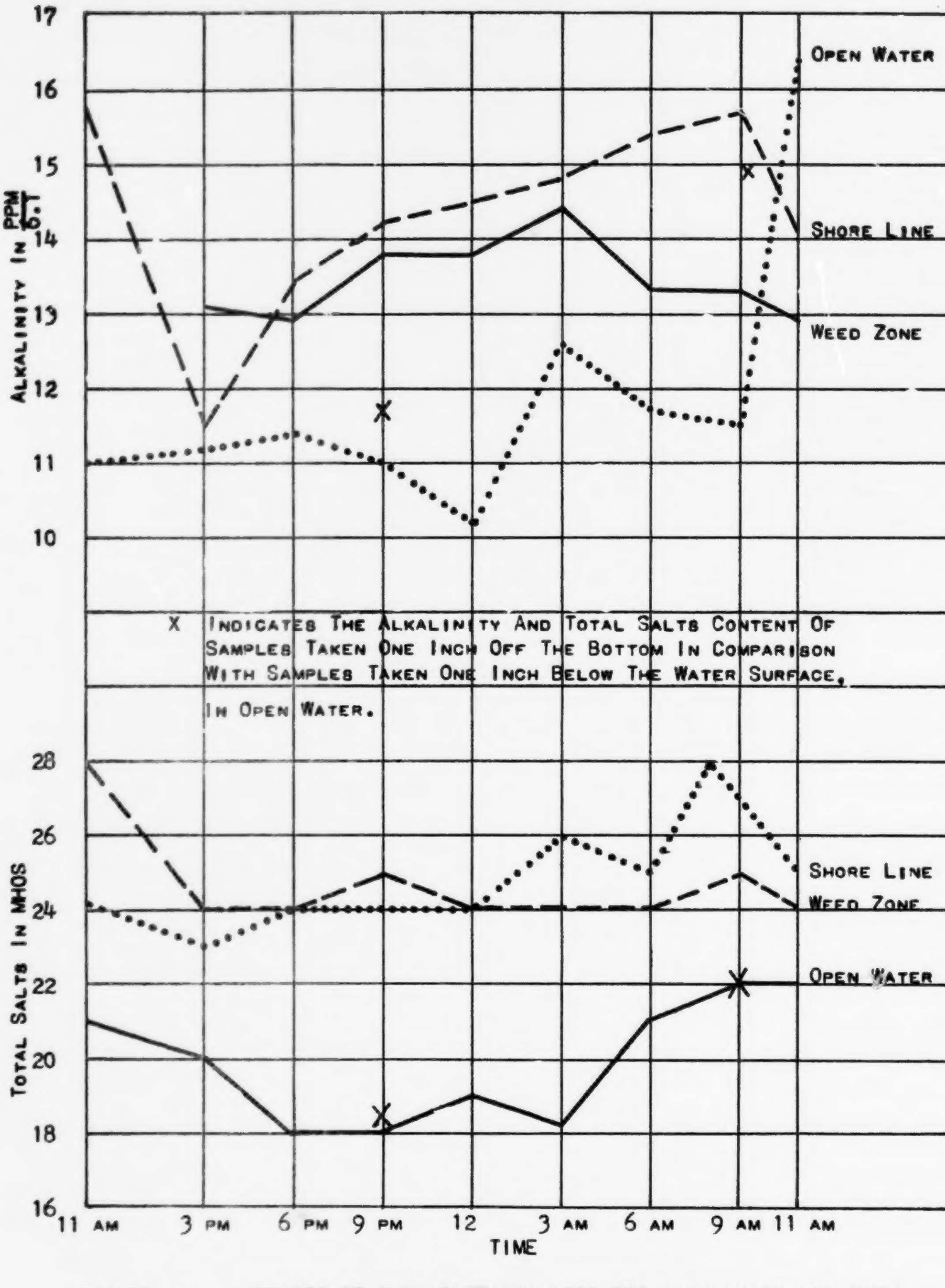


FIGURE 4. AVERAGES OF DUPLICATE ANALYSES FOR DISSOLVED OXYGEN TAKEN EVERY TWO TO FOUR HOURS FOR A 24 HOUR PERIOD. SAMPLES WERE TAKEN FROM THE SHORE LINE, ZONE OF WEED GROWTH AND OPEN WATER. SEPTEMBER 21-22, 1962. LAKE 5. LUBBOCK, TEXAS.



X Indicates The Alkalinity And Total Salts Content Of Samples Taken One Inch Off The Bottom In Comparison With Samples Taken One Inch Below The Water Surface, In Open Water.

FIGURE 5. AVERAGES OF DUPLICATE ANALYSES FOR ALKALINITY AND TOTAL SALTS EVERY TWO TO FOUR HOURS FOR A 24 HOUR PERIOD. REDUCED BY CONSTANTS FOR GRAPHIC REPRESENTATION. SEPTEMBER 21-22, 1962. LAKE 5. LUBBOCK, TEXAS.

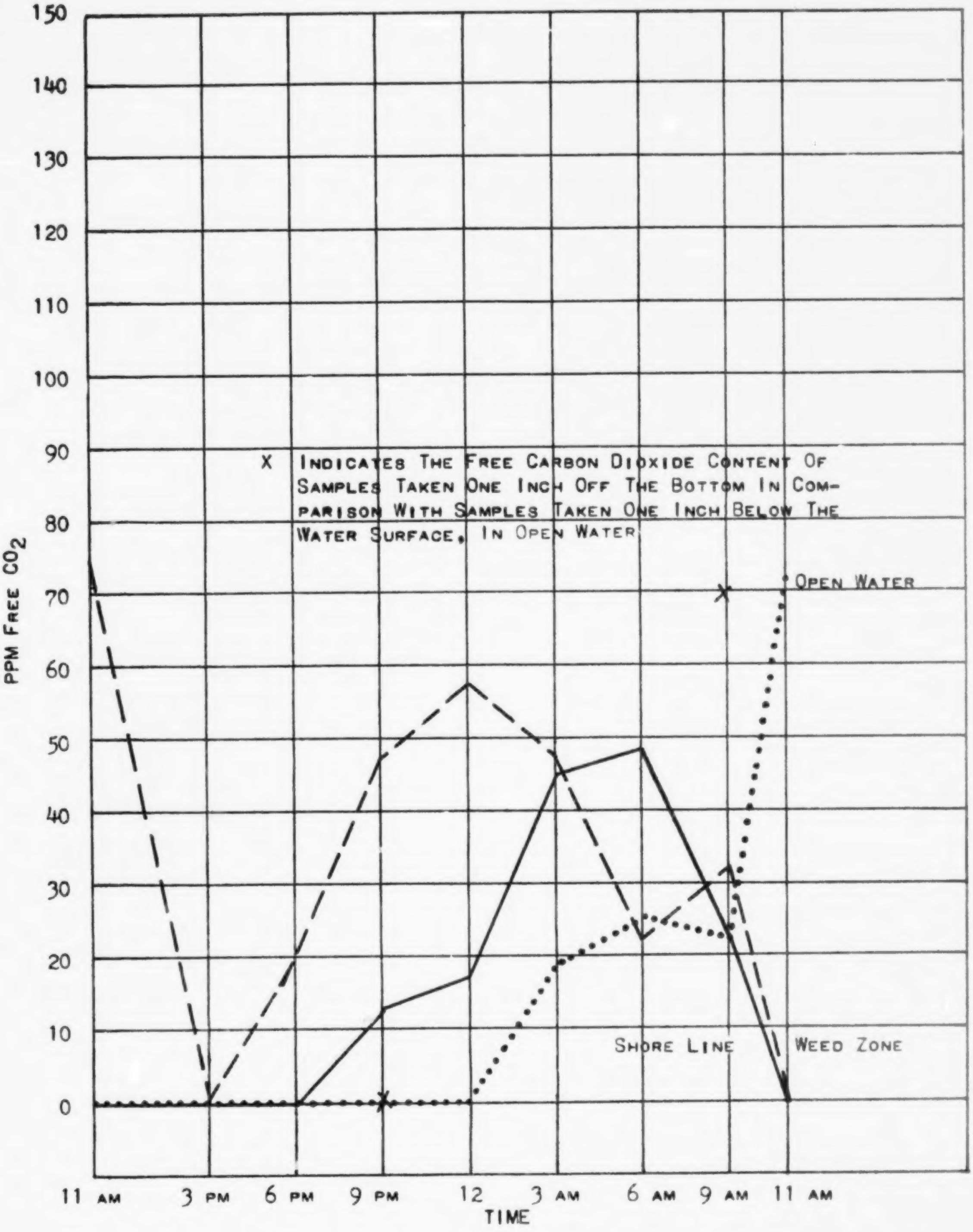


FIGURE 6. AVERAGES OF DUPLICATE ANALYSES FOR FREE CARBON DIOXIDE TAKEN EVERY TWO TO FOUR HOURS FOR A 24 HOUR PERIOD. SAMPLES WERE TAKEN FROM THE SHORE LINE, ZONE OF WEED GROWTH AND OPEN WATER. SEPTEMBER 21-22, 1962. LAKE 5. LUBBOCK, TEXAS.

PART II

ECONOMIC EVALUATION AND LAND USE STUDIES

Conducted and written by James W. Graves and David G. Moorman

Department of Agricultural Economics, Texas Technological College

16-A

ECONOMIC EVALUATION AND LAND USE STUDIES

Lubbock County, located nearly in the center of the Southern High Plains of Texas, contains 576,000 acres of generally fertile cropland, and approximately 900 playa lakes ranging in size from less than one acre to more than forty acres. Based on an estimated average size of 16 acres per lake, about 2.5 percent of the county's area or 14,400 acres are in lakes. Picture (a) in Plate I shows an aerial view of some of these lakes after heavy rains. It is interesting to note these lakes are not consistent in size or shape but at least one lake is located in nearly every square mile of this County.

Ten playa sinks have been selected in Lubbock County for intensive study to compare alternative methods by which lakes may be changed to benefit the owners and surrounding population. A factor determining the selection of these ten lakes was their ability to produce mosquitoes that might influence the occurrence of encephalitis in Lubbock County. Lakes that were picked for study were also located near highways allowing access in all types of weather. These lakes were considered to be representative of the different types that occur throughout this area. All of the selected lakes were approved by the research committee and written agreements were obtained from the land owners allowing research to be conducted on their premises.

As a means of obtaining information concerning the economic importance to agriculture of playa sinks in Lubbock County, a survey was conducted to interview a sample of owners and operators. This sample was obtained by dividing the county into quarters and picking 15 lakes at random from each quarter, giving a total of sixty lakes. At present, information has been collected on 45 of these lakes by personally interviewing the owners or operators. Interviews are being arranged with owners or operators of the 15 other lakes. The same type of questionnaire was used to obtain information about the ten lakes selected for intensive research; 8 interviews have been completed at this time. A copy of the questionnaire is included in the appendix to this report. The final results of this research survey along with an economic analysis of the data collected will form the basis of a Thesis by David Moorman in partial fulfillment of the requirements for a Masters Degree in Agricultural Economics at Texas Technological College.

SUMMARY OF INTERVIEWS WITH OWNERS OF PLAYA LAKES

A preliminary analysis of the interviews conducted among owners and operators of the 45 lakes in the sample obtained from Lubbock County indicates that the area covered by lake water averaged 16 acres. This average was obtained from replies to the first question in the schedule. The questionnaire was divided into three sections, concerned with: 1) general background information, 2) cultural practices used in and around the lake, and 3) attitudes and opinions concerned with the value of the lake and its potential importance. Some of the replies to questions in this survey are summarized below for the playa lakes studied throughout Lubbock County.

This survey showed that most lakes hold water for only one to three months out of the year, although a few contain water year around. The amount of water that collects in playa lakes varies with the amount and distribution of yearly rainfall as well as the amount of irrigation runoff or "tailwater" that is allowed to collect in the depression. Table I summarizes the replies to question 2 and 3 in Section A of this questionnaire.

TABLE I

Number of Lakes Falling Within Various Categories of Periods of Water Retention: Estimated Maximum Water Depths in 1961, 1960, 1959

Random Sample and Ten Lakes Selected for Modification

	Random Sample			Selected Lakes		
Length of time water remained in lakes: Months	1961	1960	1959	1961	1960	1959
	Number of Lakes					
0-1	12	7	9	2	2	2
1-2	4	1	1	0	0	0
2-3	8	8	4	1	0	0
3-4	4	5	2	2	1	1
over 4	3	5	5	1	1	1
no reply	17	19	24	4	6	6
Depth of water in lakes: Feet						
0-1	14	3	3	0	0	1
1-2	4	4	2	2	0	0
2-3	7	6	7	2	2	3
3-4	5	8	5	1	3	0
4-5	3	4	4	0	1	0
over 5	2	4	3	1	0	0
no reply	15	15	31	4	4	6

The depth of water in the lakes may give an erroneous impression of the amount of water in the lake since the slope of the lake sides has an important influence on the volume of water. However, farmers have little knowledge of the volume of water in their lakes and many can give only estimates of high water level depths. One owner reported that his lake had 15 feet of water in 1960, however, the majority of lakes have not had more than four feet of water in them during the past three years.

In summarizing these interviews, it is evident that there are several economic approaches to utilizing playa sinks. One approach is to attempt to eliminate water in the lake by retaining the rainwater on the land where it falls and preventing irrigation tailwater from accumulating. This is successfully accomplished on some shallow depressions with favorable soils by building terraces, level benches, or contour farming.

Approximately half of the farmers in the random survey reported that some type of modification was being used around their lakes. Terraces are most commonly found on fairly steeply sloping land around lakes. Contour farming and bench level modifications are also used, but less often. Pictures (b) and (c) in Plate I show contour farming around two of the lakes in the sample.

The attitude of farmers toward these modifications influence their success or failure to a large extent. One-half of the farmers in the sample stated that the terraces, contours, or bench levels around their lakes were beneficial in holding the water on the land and controlling erosion. Others stated that they had torn down the modifications around their lakes because of the difficulty encountered in irrigating terraced and contoured land. These farmers plant in rows running with the slope, a method which makes it easier to irrigate but generally wastes water and leads to erosion. Unless farmers understand the principles of soil and water conservation and use good management practices on the modifications around their lake, they are likely to find these methods unprofitable. Evidence from State Experiment Stations indicates that certain types of contour farming are more practical for some crops than for others. Benches have proved satisfactory to several of the farmers interviewed both in crop production and preventing rainfall runoff from occurring.

A second approach toward playa sink management is to minimize erosion on land surrounding the lake and modify the lake bed itself to allow water to be pumped from the lake for irrigation. By excavating a pit or ditch in the lake bed the accumulated water can be confined to a smaller surface area, evaporation reduced, more land made available for cultivation and a lake pump can be installed to pump the water for irrigation. Irrigation costs from lakes are below those from wells, and lake water has proven to be of greater value to crops. The type of excavation most desirable for a playa lake appears to depend on the lake size and shape, the soil conditions in the lake and on the surrounding runoff land and the purposes for which the water is to be used. Further study needs to be made of this problem before guides can be established to advise farmers.

One-fourth of the farmers surveyed in the sample indicated that they had made some modifications in their lake bed to concentrate the water and allow them to pump from the lake. These modifications were small pits usually placed in the lowest part of the lake where a lake pump is then installed. Figure (d) in Plate I shows a lake pump installed on a playa sink in the area. After a pit has been dug it must be cleaned out frequently to prevent silt from filling it again. Figure (e) in Plate I shows a pit that has been partially filled by blowing sand within a few days after it had been excavated. This together with the fact that in most cases when rainwater collects in the lake there is no immediate need for irrigation has discouraged several farmers from modifying their lakes in this manner.

A few farmers in Lubbock County have attempted to use recharge wells in connection with their playa sinks. In many cases such attempts have not proven successful because of silting and clogging in the well and resulting cave-ins when water was pumped back out.

No really successful filter has been developed at this time which will remove the silt and clay particles from the water going into the well. A recharge well could conserve water for future use but impose the additional cost of pumping the well for irrigation rather than pumping directly from the lake itself. None of the farmers sampled had found success with using recharge wells in connection with their playa lakes.

A final approach toward the utilization of playa lakes is concerned with a modification which will allow the lake to be used for recreational purposes. In the Lubbock area there are several golf courses that have been built around playa lakes. Picture (f) in Plate I shows part of one such golf course and the natural depression used as a water hazard. For this solution to be successful, these lakes should contain water throughout most of the year and be located close to an urban area where such recreation is in demand. One other lake in the sample was being used in a golf course and the owners were concerned with how they might best modify the lake bed to conserve and utilize the water most efficiently. Further research may indicate possibilities of stocking some lakes with fish or developing bird hunting areas around some of these natural depressions to satisfy the demand by sportsmen for more fishing and hunting. As the population's average income and leisure time increases, it is to be anticipated that the demand for recreation will also grow. Lubbock County has a shortage of recreational areas at present and unless positive action is taken on developing more local facilities, shortages will become more severe.

At present many farmers are trying to grow crops or pastures in their lake beds. Over half of the farmers surveyed reported that they plowed their lake beds during dry periods. Most of these were planted to a crop, either cotton, pasture, or a small grain. In some instances, extremely high yields were reported for crops grown in the lake beds due mainly to the relatively abundant available water and fertile soil. Of course, flooding and standing water prevented harvesting of many crops but in one case it was reported that Bermuda grass pasture withstood two months of submersion.

Government programs have greatly influenced agricultural use of land in recent years. Farmers in Lubbock County have had more land than allotted cotton acreage and as a result there has been no shortage of acreage. However, in 1962 the Department of Agriculture allowed farmers to spread their allotted cotton acreage over twice the land area by permitting farmers to alternatively plant two rows in cotton and leave two rows idle. Using such a plan farmers can increase production per allotted acre. As a result the land in playa lakes has been of increasing concern to farmers in the past year. Recently many farmers have obtained some income from their lakes by putting them under the government program of acreage diversion. More than half of the farmers interviewed had used their lakes in this manner in recent years. If the present program of allowing cotton allotments to be spread over twice as many acres continues, it is anticipated that greater emphasis will be placed on recovering farm land from playa lake beds.

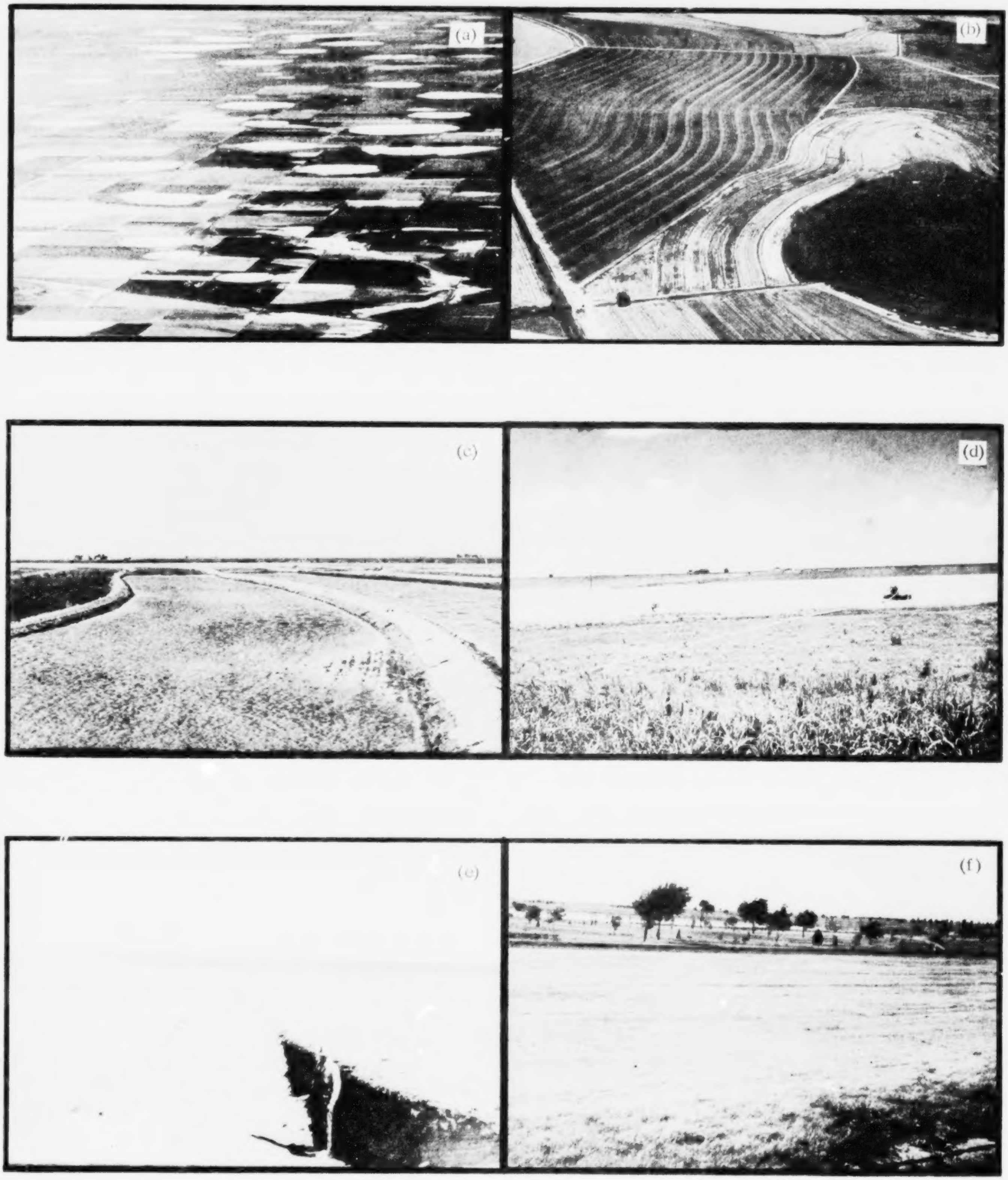
Farmers interviewed in this survey showed considerable interest in the cooperative research program concerned with modifying playa sinks. They raised questions of management and control of playa lakes. They were generally interested in reducing water evaporation and utilizing their lake as well as recovering land for agricultural purposes. Most of the farmers recognize these lakes as sources of mosquitoes and wanted to know efficient methods of controlling lake insects. Answers to their questions are not yet available, but results from this cooperative research will be valuable in providing guides by which to advise these farmers with land adjacent to or in playa lakes.

The survey of the lakes throughout the county indicated that the sample selected for modification was quite representative of all lakes in the county. Although problems differ from lake to lake, a solution of some of these problems on the lakes selected for modification will be beneficial to many farmers throughout the Southern High Plains in attempting to modify their lakes. It will be necessary to evaluate the costs and returns of these modifications over a period of several years to obtain information that can be useful to other farmers in the area. Lake modification should be viewed as a long term project and there will be continuing maintenance costs to almost any modification as well as long run benefits.

SUMMARY OF RESEARCH CONDUCTED IN AGRICULTURAL ECONOMICS

Two members of the staff of the Agricultural Economics Department at Texas Technological College have been conducting research on the economic utilization of playa sinks on the Southern High Plains of Texas during the past year. Realizing the potential importance of these lakes to the agricultural production of the area in the future, a survey of farmers throughout Lubbock County was undertaken by David Moorman, a graduate student, to determine the present usage of playa lakes and the attitudes and problems of the farmers who farm the land around such lakes. Farmers evidenced considerable interest in this research and many perplexing questions were raised. It was obvious that efficient use was not being made of the majority of these lakes currently, but this source of water for future use will become important. Maximum benefits from such lakes may likely be realized only when multipurpose use is made of them. They can become a source of irrigation water and valuable cropland can be recovered for agricultural production. Farmers are beginning to realize these potentials and desire more information concerning modifications that would prove economical.

Plate III



PART III

HYDROLOGY AND ENGINEERING

Conducted and Written by Don L. Reddell

William L. Broadhurst, and A. Wayne Wyatt

High Plains Underground Water Conservation District

and

F. A. Rayner

Texas Water Commission

HYDROLOGY AND ENGINEERING

INTRODUCTION

The purpose of this section of the report is to evaluate the hydrological data collected during the year 1961-62. Special attention is given to the mapping of the lake beds and the installation of necessary hydrological equipment.

The fieldwork of the project was started in September 1961. The initial field work consisted of selecting several lakes for study, getting agreements with the land owners to permit studies to be made on their lakes, and installing rain gages and staff gage posts. Other fieldwork consisted of mapping the lake beds, installing staff gages, installing automatic water-level recorders, and collecting data from the lakes after they received some runoff.

Five automatic water-level recorders were loaned to the Project by the Texas Water Commission.

The soil samples which were taken from the lake bottoms were examined by Mr. Bill Koos, Soil Conservation Service, Lubbock, Texas.

All the hydrological investigations were made under the direct supervision of W. L. Broadhurst, Chief Hydrologist, High Plains Water District, Lubbock, Texas.

TOPOGRAPHY

Mapping of Drainage Area

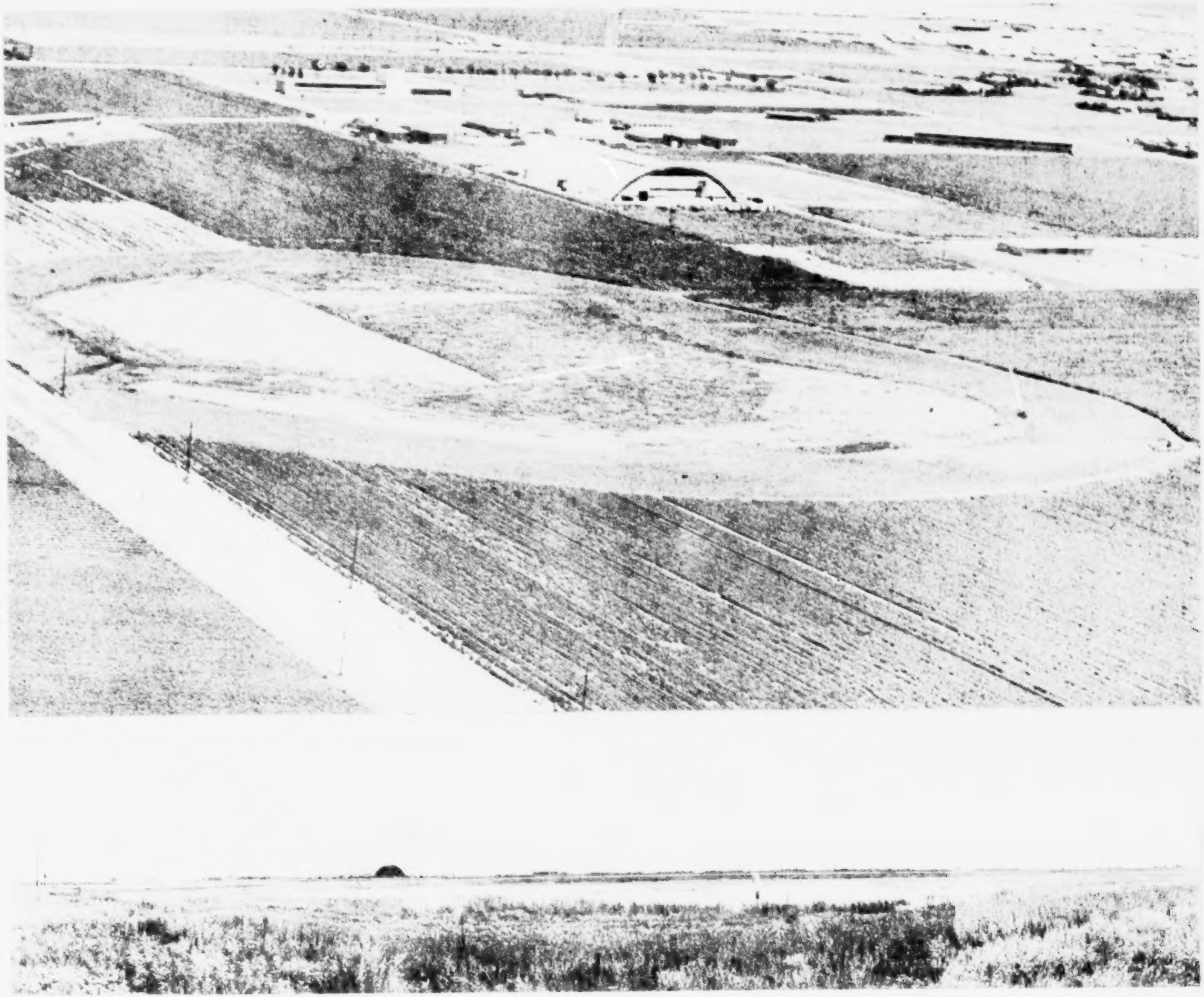
Since the drainage areas of the lakes remain relatively constant, the lakes' water sheds can be surveyed at any time without the loss of valuable information. For this reason, the determination of the water shed area of each lake was postponed until other pertinent duties could be performed. As of August 31, 1962 maps had not been made of the lakes' drainage areas.

Mapping of Lake

Topographic maps of the lake beds (area subject to coverage by water) were made for 10 lakes in Lubbock County, Texas.

These lakes were surveyed with a transit or plane table and alidade. The elevations of the ground at various points (usually every 100 to 150 feet) over the entire lake area were determined. These elevations were related to an assumed datum assigned to a selected bench mark in each lake.

With these numerous ground level elevations, contour lines with a one foot interval were drawn for each lake.



LAKE NO. 4, LUBBOCK CHRISTIAN COLLEGE Plate IV

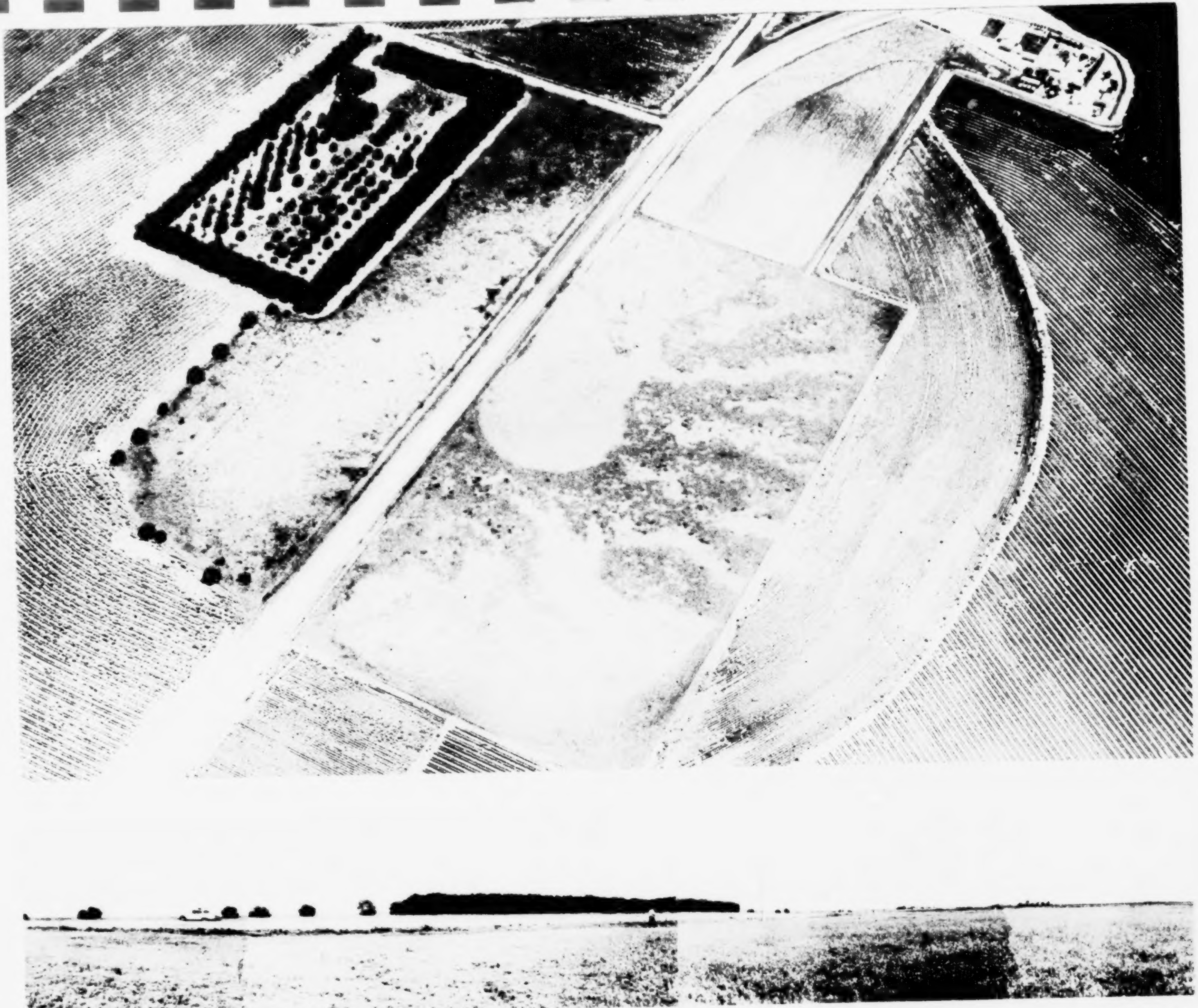


Plate V

LAKE NO.5, C.K. & W.M. KITTEN

Maps of the lakes were drawn to a scale of one inch equals 100 feet. Copies of the original maps, to a reduced scale, are contained in Appendix I. These maps show the land surface configuration for each of the 10 lakes selected for study. Aerial and Panoramic photographs of two of these lakes are shown in Plates IV and V.

Elevation-Area and Elevation-Volume Curves

Elevation-volume curves and elevation-area curves were constructed for each of the 10 study lakes.

The area within each contour interval on the topographic maps was determined with a planimeter. This area was then plotted along the abscissa and the elevation corresponding to each contour was plotted along the ordinate. A curve was then drawn connecting each point. This is the elevation-area curve.

The volume within each contour interval was determined by the end-area formula. This formula has the following form:

$$\frac{A_1 + A_2}{2} h$$

where h is the contour interval and A_1 and A_2 are the areas within adjacent contours. The volume within each contour interval was then plotted along the abscissa and the elevation corresponding to each contour was plotted along the ordinate. The curve connecting each of these points is the elevation-volume curve.

Copies of the elevation-volume and elevation-area curves are contained in Appendix I. Knowing the water surface elevation in a lake, the volume of water contained in the lake and the surface area of the lake can be determined by using these curves.

EQUIPMENT USED TO COLLECT HYDROLOGICAL DATA

Rain Gages

Rain gages of the type shown in Plate VI, Picture No. 5 were installed at all 10 of the selected lakes. The rain gage consists of a glass tube approximately 5/8 of an inch in diameter and 5 3/4 inches long. The glass tube is held in place by a graduated metal container. Rainfall is determined by measuring the inches of water which has collected in the tube.

This type of rain gage is probably less accurate than a recording gage; however, the accuracy is adequate for this project.

The main disadvantage of this type of rain gage is that it is non-recording and necessitates frequent field visits.

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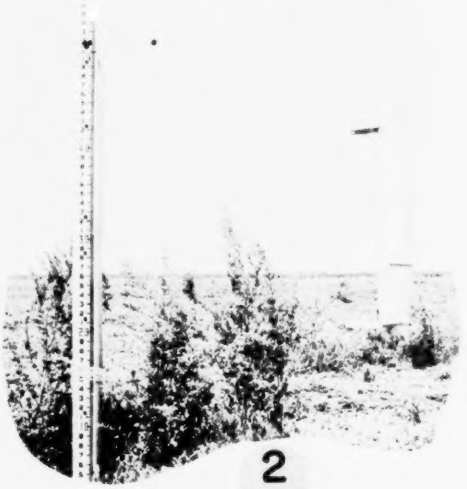

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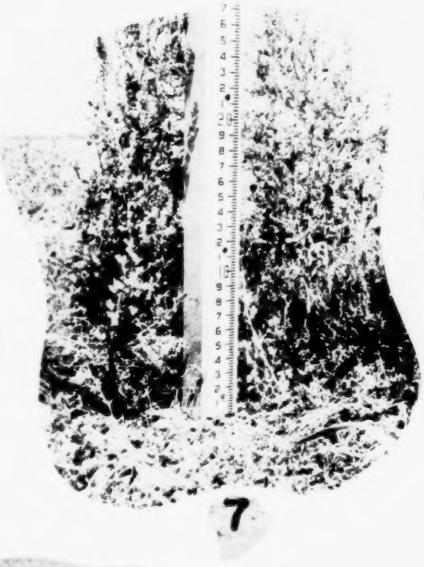

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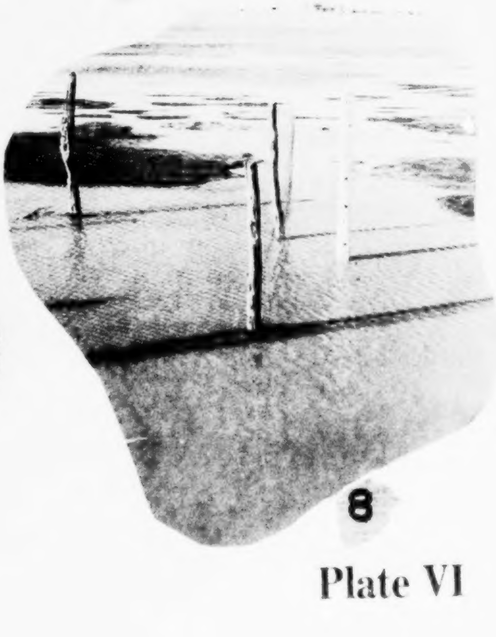

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LAKES NO. 1,3,4,6 &7

Plate VI

The cumulative total amount of precipitation at any lake for the year 1962 (see Figures 1 through 8, Appendix II) is reasonably accurate. However, the distribution of rainfall as shown in the histograms of Figures 1 through 8 (Appendix II) probably contains some minor errors.

Staff Gages

Staff gages of the type in Plate VI, Picture Nos. 2 and 7, were installed in eight of the ten selected lakes. These staff gages consist of narrow strips of metal graduated into hundredths of a foot. The gages were bolted to 4-inch by 4-inch wooden posts which were set in about two feet of concrete.

The staff gage at each of the eight lakes was set at a known elevation. When water entered the lake, the elevation of the water surface could be determined by reading the depth of water around the staff gage.

The main disadvantage of the staff gages is the same as that of the previously described rain gages; they are non-recording. Because of the inability to visit each lake every day, many water level fluctuations could occur without ever being recorded. Automatic water-level recorders, which were installed in five of the lakes, eliminated this problem.

Automatic Water-Level Recorders

To effectively record water-level variations, three Leupold-Stevens Type F recorders and two Leupold-Stevens Type FM recorders were installed in five selected lakes (Lakes 1, 2, 3, 4, and 6).

The Type F recorders have an inking stylus which is driven by a hand wound clock across a drum mounted chart, 9.6 inches long, at the rate of 1.2 inches per day. This type of recorder has to be serviced every 7 days (see Plate VII - Picture No. 6 and 7).

The 0.3 inch per day horizontal movement of the inking stylus on the Type FM recorder is controlled by a weight driven clock. This type of recorder has to be serviced every 31 days. (see Plate IX, pictures 2 through 9).

The drum mounted charts rotate in response to the vertical movement of a 4-inch float (see Plate VII - Picture No. 1).

The geared ratio of the vertical changes in elevation of the float to the rotation of the recorder drum determines the magnitude of the recording of water level variations.

Three recorders (Lake 1, 4 and 6) have a ratio of two feet of vertical float movement to each complete rotation of the recording drum. The recorder installed in the Hufstedler Lake (Lake No. 3) has a ratio of one complete drum rotation for every 5 feet of vertical float movement. The recorder installed in Lake No. 2 (Knowles) has a ratio of one to one.

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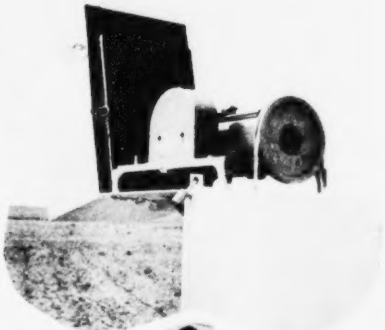

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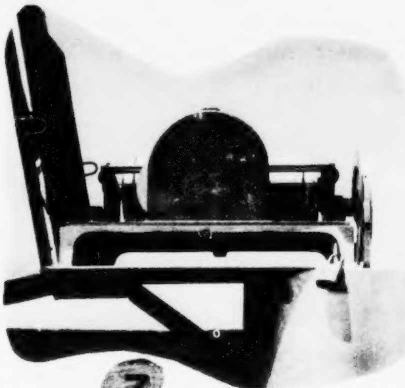

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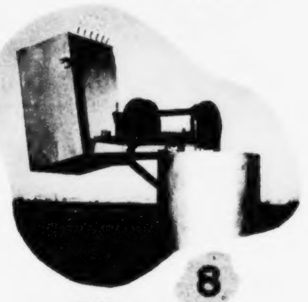

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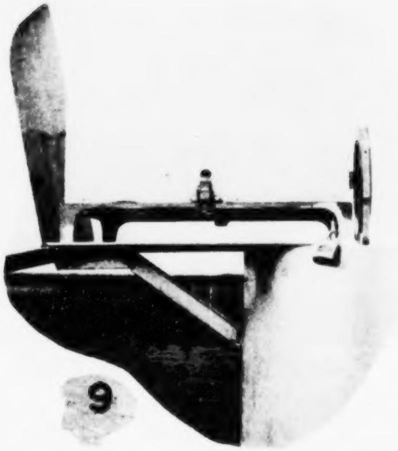

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LAKES NO. 1,3,4 & 6

Plate VII

Based on the operations of these recorders during this summer season (1962) the type FM recorder with the 2 to 1 gear ratio appears to be preferable for this type of survey. During a more prolific water year (as an example, 1960) the higher gear ratio of 5 to 1 would probably be best adapted to recording lake levels.

These recorders have been of immense value to the Project because they have eliminated guess work in determining variations in lake levels.

The water-level recorders are installed atop 7 foot (above land surface) towers in Lakes Nos. 1, 3, 4 and 6 and an 11 foot (above land surface) tower in Lake No. 2 (see Plate VI - Picture Nos. 1, 2, 3, 4, and 6; Plate IX - Picture Nos. 2 and 3 and others).

The hinge mounted protective cover (see Plate VII - Picture Nos. 5, 6, 7, and 8; Plate IX - Picture Nos. 7 and 8, and others) provides weather and vandalism protection for the recorder (including recorder dust cover, see Plate VII - Picture 9). This heavy duty cover also functions to provide an air space protecting the recorder in the event of complete inundation (designed to withstand submergence approaching 7 feet). A steel screen (see Plate VII - Picture No. 6 and 8, and others) welded to the recorder cover prevents access to the upper end of the tower (when cover is locked in place, see Plate VII - Picture 5, 6, 7 and 9, and others) and limits the upward movement of the float in the case of complete submergence.

The 12 inch casing, forming the body of the tower, provides protection for the float and its attached cable, and serves as a stilling well, dampening wave action, to guide the vertical movement of the float.

A 6-inch by 8-inch opening at the base of every tower (see Plate VII - Picture No. 1 and Plate VIII - Picture No. 3 and 7) provides access to the stilling well for removal of mud and other foreign material (access also necessary in pouring and finishing the concrete base of the stilling well).

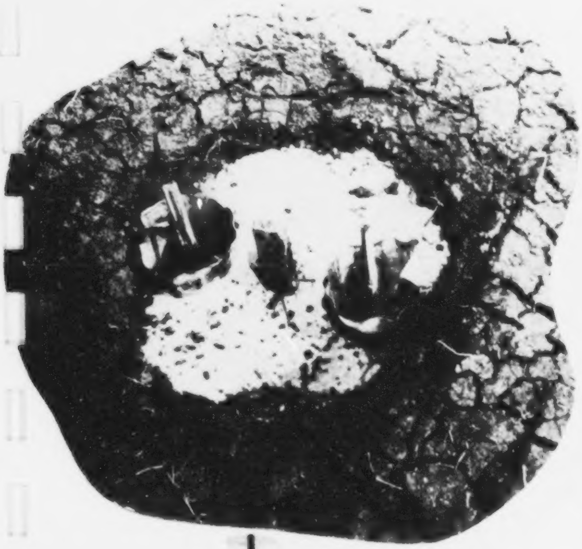
A snug fitting door (see Plate VII - Picture 1 and 10) covers the cleanout opening.

Two vertical slots 1/8-inch wide by 4-inches high, in the access door and directly opposite in the casing wall (see Plate VII - Picture No. 1 and 10 and Plate VIII -Picture No. 7) provide the only access, by water, to these towers.

Service platforms for the 7-foot towers are illustrated by Picture Nos. 2, 3, and 4, Plate VII and Picture Nos. 1, 2, 3, 4 and 6, Plate VI.

Steps of the 11-foot tower (Lake No. 2) consist of 1/8-inch by 1 1/2-inch angle iron, with slip guards welded to both ends (see Plate VIII - Picture Nos. 3, 4, 5, 6, 7 and 8 and Plate IX - Picture Nos. 2, 3, and 4).

The 11-foot tower is fitted with a safety bar (see Plate VIII - Picture Nos. 4, 5, and 6 and Plate IX - Picture Nos. 1, 2, 3, 4, 5, 6, 7 and 8).



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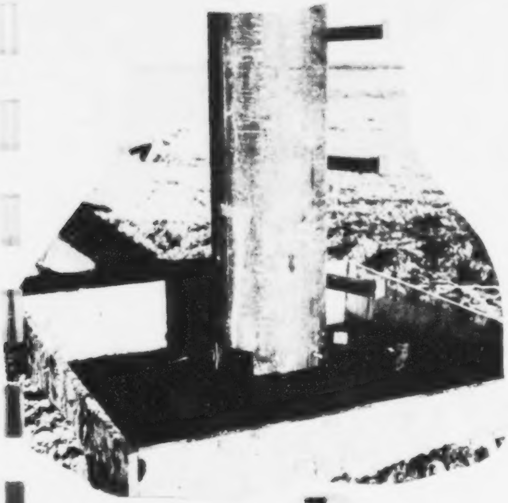

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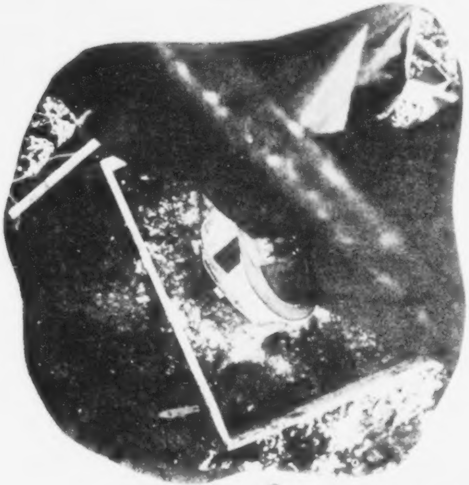

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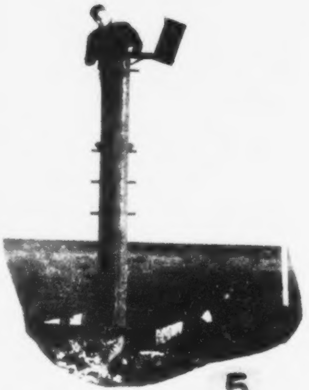

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LAKE NO. 2, M. KNOLES

Plate VIII

These towers were installed over a subfoundation consisting of about 2-inches of concrete 16-inches in diameter, set about 6-inches below ground level (see Plate VIII-Picture 1, top of center peg is at a selected elevation, near ground level, and will mark the base of the stilling well of the completed tower). Two four foot lengths of 3/16-inch by 1 1/2-inch angle iron, bolted to the casing and set in 4-inch (diameter) holes filled with concrete (one angle iron support is bolted to the lower step of the 7-foot towers) provide support for the tower assemblies (see Plate VI - Picture Nos. 1, 2, 3, and 6, Plate VII - Picture 1, 2, and 4, and Plate VIII - Picture Nos. 3, 7, and 8).

An 18-inch diameter by 6-inch thick reinforced concrete base was poured around and in each tower.

These towers have functioned in accordance with their design specifications.

HYDROLOGICAL DATA COLLECTED AND COMPUTED

Irrigation Runoff

With the staff gage readings and water-level recorder readings, elevations of the water surfaces in each of the lakes were determined. The recorders gave a continuous record of water levels and the staff gages were read about twice a week.

With the aid of the rainfall data, and visible inspection of the lakes, estimates of the amount of irrigation runoff (tailwater) were made and are given in Table II.

TABLE II - Estimated Volume of Irrigation Runoff Received by each Lake during the Summer of 1962.

Lake	Volume in acre-feet
Lake No. 1 (Huckabee)	None
Lake No. 2 (Knoles)	1.0
Lake No. 3 (Hufstedler)	1.0
Lake No. 4 (L. C. C.)	[1]Neg
Lake No. 5 (Kitten)	0.5
Lake No. 6 (Holland	0.5
Lake No. 7 (Cooper)	9.0
Lake No. 8 (Burgett)	No record kept
Lake No. 9 (Cox)	None
Lake No. 10 (Dupree)	[1]Neg.

[1]Neg. - Indicates that the total volume was something less than 0.5 of an acre-foot.

The only lake that received any significant amounts of irrigation tailwater was the Cooper lake. It received an estimated 9.0 acre-feet. A lake pump has been installed in this lake with a flow meter to record the amount of water pumped from the lake. A total

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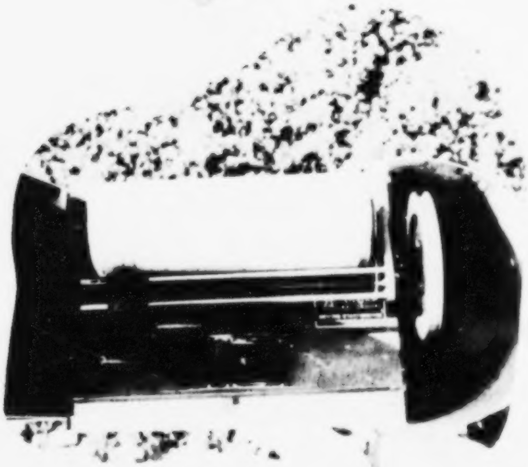
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LAKE NO. 2, M. KNOLES

Plate IX

volume of 17.1 acre-feet of water was reclaimed from the lake. Therefore, an amount equal to the total of all the tailwater runoff was reclaimed from this lake as well as some rainfall runoff.

Rainfall Runoff

With the staff gage readings and elevation-volume curves, the volume of rainfall runoff for each lake was calculated.

This runoff, when compared with the rainfall data (see Figure 1 through 8, Appendix II), varies considerably with the amount of rainfall. For instance, some of the lakes would receive four or five acre-feet of runoff from a 0.5-inch storm at one time during the year and no runoff for a similar 0.5-inch storm later in the year. This shows that the condition of the watershed of each lake is an important factor contributing to the rainfall runoff.

The total amount of water caught by each lake during the summer of 1962 is shown in Table III.

TABLE III - Total amount of water caought by each lake during the summer of 1962

Lake	Volume in acre-feet
Lake No. 1 (Huckabee)	None
Lake No. 2 (Knoles)	14.7
Lake No. 3 (Hufstedler)	5.8
Lake No. 4 (L.C.C.)	34.4
Lake No. 5 (Kitten)	148.3
Lake No. 6 (Holland)	7.5
Lake No. 7 (Cooper)	66.2
Lake No. 8 (Burgett)	No record kept
Lake No. 9 (Cox)	None
Lake No. 10 (Dupree)	17.2

A lake pump was installed at Lake No. 4 (L.C.C.) in July 1962. By August 31, 1962, this lake pump had reclaimed a total amount of 5.4 acre-feet of water.

The cumulative volume of water caught by each lake, the cumulative rainfall at each lake, the daily volume of water in each lake, the daily surface area of each lake, and a histogram of the rainfall at each lake are shown in Figures 1 through 8 (Appendix II). No curves were drawn for Lake No. 1 (Huckabee) and Lake No. 9 (Cox) because no water was caught by these two lakes through August 31, 1962. No curve was drawn for Lake No. 8 (Burgett) because no record of water-level fluctuations was kept for this lake.

Evaporation

Evaporation data for this study is in the process of being collected and analyzed. Daily evaporation data from a standard Weather Bureau Type A pan at the Lubbock Agricultural Experiment Station has been collected for the months of January through June of 1962. Data for the months of July and August of 1962 are unavailable at this time. Because the evaporation data is incomplete, analyses of evaporation during the year of 1962 has been postponed until a later date.

Transpiration

Transpiration losses from the lakes probably amounts to a substantial quantity. However, no plans have been made to determine the amount of water lost from the lakes by transpiration.

Percolation

No analysis of the lake soils for permeability were made. However, past investigations on the Southern High Plains have shown that the soils in the bottoms of the lakes are relatively impermeable.

Two of the lakes in this study appear to lose large quantities of water by percolation. Further observation of these two lakes is needed before any definite donclusions are drawn. These two lakes are Lake No. 5 (Kitten) and Lake No. 7 (Cooper).

By comparing the daily volume of water curve in Figures 5 and 7 with the daily volume of water curve in Figures 1, 2, 3, 6 and 8 (Appendix II), the rate of water loss in the Kitten Lake and Cooper Lake is considerably larger than in the other lakes.

SOIL SURVEY

Auger Samples

About 130 soil samples were taken from six of ten lakes under study. These samples were taken with a hand auger. From three to five test holes were dug in the bed of the lakes with about three to ten soil samples being taken from each hole. The test holes were not plotted on the contour maps. Table IV contains the sample logs from several of the test holes which were drilled into the lake bottoms.

TABLE IV - Sample logs of test holes in several lakes included in the lake study

Texture	Depths In Inches	Reaction	Visible Determination of Permeable
	Lake No. 1	(Huckabee)	
Clay Loam	0-12	Non-Calcareous	Slowly Permeable
Clay Loam	12-24	Very Strongly Calcareous	Slowly Permeable
Clay Loam	35-36	Very Strongly Calcareous	Slowly Permeable
	Lake No. 3	(Hufstedler)	
Clay	0-48	Non-Calcareous	Very Slow
Clay Loam	48-60	Non-Calcareous	Slowly Permeable
Sandy Clay Loam	60-72	Non-Calcareous	Moderate
Clay Loam	72-93	Non-Calcareous	Slowly Permeable
	Lake No. 4	(L. C. C.)	
Clay	0-48	Weakly Calcareous	Very Slow
Clay	48-84	Strongly Calcareous	Very Slow
Clay Loam	84-96	Strongly Calcareous	Slowly Permeable
Sandy Clay Loam	96-130	Strongly Calcareous	Moderate
	Lake No. 6	(Holland)	
Clay	0-24	Non-Calcareous	Very Slow
Sandy Clay Loam	24-36	Very Strongly Calcareous	Moderate
Clay Loam	36-60	Non-Calcareous	Slowly Permeable
Sandy Clay Loam	60-96	Non-Calcareous	Moderate
Clay Loam	96-112	Non-Calcareous	Slowly Permeable
Sandy Clay Loam	112-144	Non-Calcareous	Moderate
	Lake No. 8	(Burgett)	
Clay	0-48	Non-Calcareous	Very Slow

TABLE IV - continued

Texture	Depth In Inches	Reaction	Visible Determination of Permeability
Clay Loam	48-96	Non-Calcareous	Slowly Permeability
Sandy Clay Loam	96-132	Non-Calcareous	Moderate
Clay Loam	132-144	Non-Calcareous	Slowly Permeable
Sandy Clay Loam	144	Non-Calcareous	Moderate
	Lake No. 9	(Cox)	
Clay	0-36	Non-Calcareous	Very Slow
Heavy Clay Loam	36-48	Non-Calcareous	Slowly Permeable
Sandy Clay Loam	48-72	Non-Calcareous	Moderate

Soil Map

No soils maps for the lakes were made during the past year. Future investigations should provide for the compiling of a soils map for each of the lake beds.

PLANS FOR MODIFICATION

Some preliminary calculations for cuts and fills have been made for Lake No. 3 (Hufstedler) and Lake No. 4 (L. C. C.). These calculations are still in the preliminary stages and no definite conclusions can be drawn.

PART IV

PROJECTED INVESTIGATONS AND WORK PLANS

Progress Staff

DIRECTED AND ADMINISTERED BY

Dr. David M. Cowgill

Director, Lubbock City-County Health Unit

and

Mr. William L. Broadhurst

Chief Hydrologist, High Plains Underground Water Conservation District

COORDINATED BY

Mr. Walter Breedlove

Chief Public Health Engineer, Lubbock City-County Health Unit

WORK PLANS FOR THE BIOLOGICAL PHASES OF THE STUDY

A base line has been established by biological studies of the previous season; work plans for next season includes a continuation of these studies on the modified playas. This will yield a good indication of the success of the modification for mosquito control. In evaluating this data it can be determined what factor or factors of the playa environment were changed to give mosquito control and what effect these changes had upon other invertebrate and vertebrate fauna and flora.

Sampling techniques used the previous season will be statistically evaluated and modified for the next season. Preliminary evaluation of these techniques indicates an over-sampling of lakes for mosquito production on single sampling dates. Also the water chemistry data indicates that less frequent samplings can be made. The data on mosquito production shows a definite need for frequent sampling; therefore during the coming season plans have been made to sample lakes twice a week but with fewer samples per sampling date. As for water chemistry and water temperature, plans are being made to sample lakes more intensively per sampling date but less frequently.

With the time saved in modifying these sampling techniques other important phases of the study can be investigated more intensively. Among these are light trap studies and life-history studies on the laboratory cultures. This will also allow for the incorporation of additional lakes into the study, giving broader, more meaningful results.

Also included in the work plans for the coming season is evaluation of the correlation between depth, vegetative cover, and mosquito larvae numbers. Both correlation and regression analysis will be made from the data already derived from the study and these hypothesis will then be tested in the field.

FUTURE RESEARCH NEEDED IN AGRICULTURAL ECONOMICS

An economic analysis of various modifications on playa lakes needs to be made to determine realistic costs and returns. Further research is needed to determine the returns to be expected from playa lake use and the possibilities of multipurpose utilization. Costs of the different approaches to playa lake use needs to be compared to set up guides by which individual farmers can plan modifications of their own lakes. The concept of long run benefits to lake owners, their neighbors, and the population of the Southern High Plains in general that will result from efficient use of the many existing playa lakes needs to be investigated and results published. In this area where water shortages are becoming more severe, the inefficient use of lake water is an increasing cost to all of the population resulting in less water for human consumption, greater mosquito infestations, reduced agricultural land areas, lower farm incomes, and higher costs of agricultural products than would be possible under proper lake management. Research that can help solve problems of proper lake management will result in broad benefits to the area.

WORK PLANS FOR THE HYDROLOGICAL PHASES OF THE STUDY

During the fiscal year September 1, 1962-October 31, 1963, plans include complete modifications of two playa lakes and partial modification of a third one.

Bids were received on December 18, 1962, for modification of lakes 3 and 4, Hufstedler and L. C. C. According to plans prepared by Parkhill, Smith and Cooper, consulting Engineer, the two lakes will require cuts amounting to about 67,000 cubic yards. Preliminary reviews of bids indicate that cost of modification will be about 19 or 20 cents per cubic yard for a cost of about $13,000.00

It is contemplated that a metal or concrete drop will be installed to let water into the pit and thus prevent excessive erosion into the barrow pit.

In order to comply with request of the Lubbock Planning and Zoning Commission, the L. C. C. pit will have side slopes of 10 to 1; the Hufstedler pit will have 2 to 1 side slopes and 5 to 1 end slopes. By using the steeper slopes the water surface area per acre-foot of water in the pit can be reduced considerably and consequently reclaim more land and also reduce evaporation from the water surface.

A large-capacity lake pump is being prepared so that storm runoff may be pumped from the lakes rapidly should heavy rains occur before modification is completed. L. C. C. lake now contains some water which will be removed by pumping as soon as construction is started. A low dam will be built around the cut area to prevent light or moderate runoff from entering the barrow pit.

If weather is favorable, at least the two lakes should be completed before spring rains.

Hydrologic data will be collected for most all lakes that were observed during 1962; and detailed data will be collected for a few additional lakes on or adjacent to the major highways leading into Lubbock.

APPENDICES

I. Lake Bed Contour Maps and Elevation-Area and Elevation-Volume Curves

II. Hydrological Data

III. Mosquito Larvae Dipping Forms

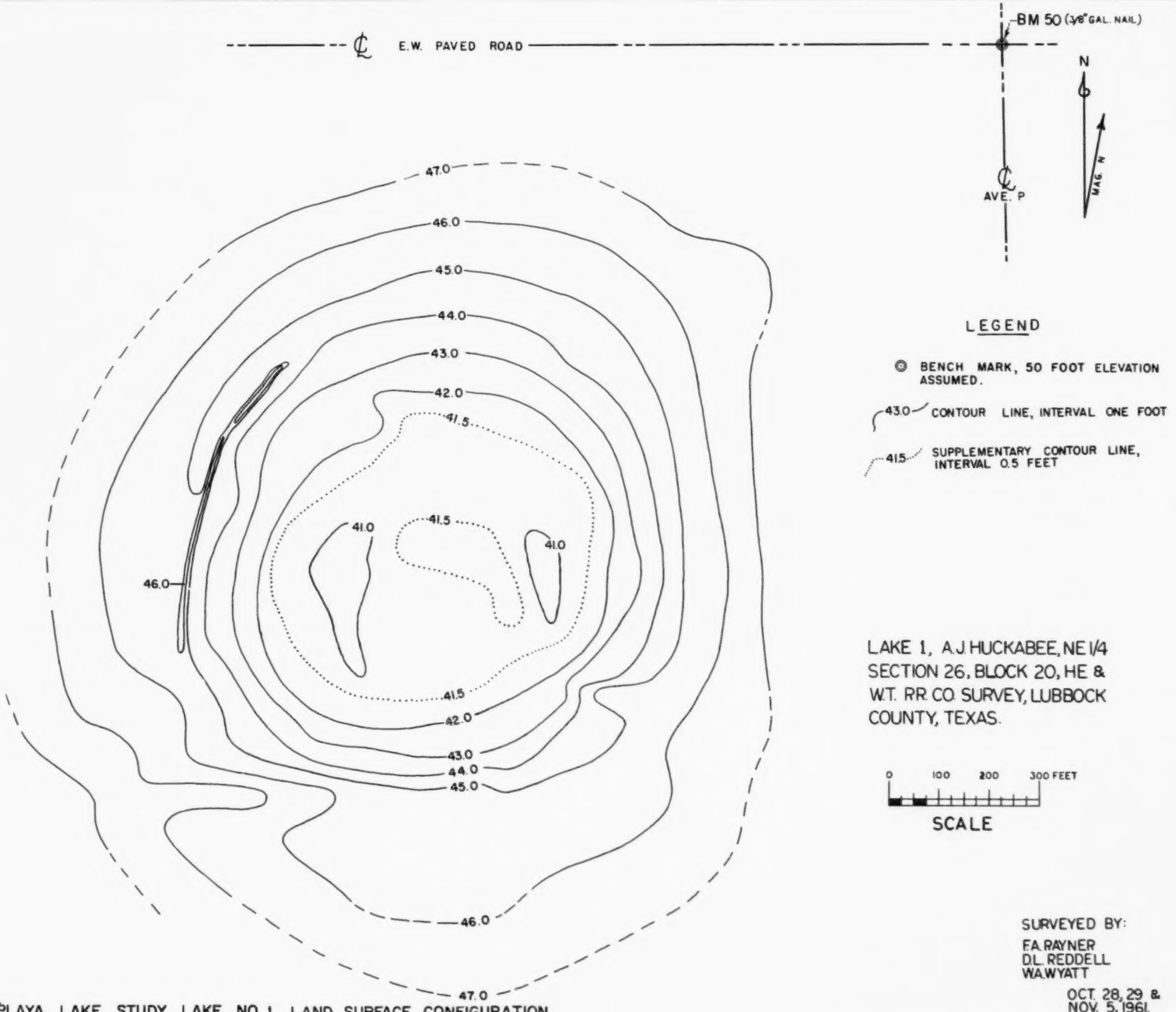
IV. Mosquito Larvae Production Graphs

V. Water Chemistry Data

VI. Floral and Faunal Checklist

VII. Economic Survey Form

APPENDIX I. Lake Bed Contour Maps, Elevation-Area and Elevation-Volume Curves


E.W. PAVED ROAD
BM 50 (3/8" GAL. NAIL)
N
MAG. N
AVE. P
47.0
46.0
45.0
44.0
43.0
42.0
41.5
41.0
41.5
41.0
46.0
41.5
42.0
43.0
44.0
45.0
46.0
47.0
0
100
200
300 FEET
SCALE

LEGEND

◎ BENCH MARK, 50 FOOT ELEVATION ASSUMED.

43.0 CONTOUR LINE, INTERVAL ONE FOOT

41.5 SUPPLEMENTARY CONTOUR LINE, INTERVAL 0.5 FEET

LAKE 1, A.J. HUCKABEE, NE 1/4
SECTION 26, BLOCK 20, HE &
W.T. RR. CO. SURVEY, LUBBOCK
COUNTY, TEXAS.

SURVEYED BY:
F.A. RAYNER
D.L. REDDELL
W.A. WYATT

OCT. 28, 29 &
NOV. 5, 1961.

PLAYA LAKE STUDY, LAKE NO. 1, LAND SURFACE CONFIGURATION

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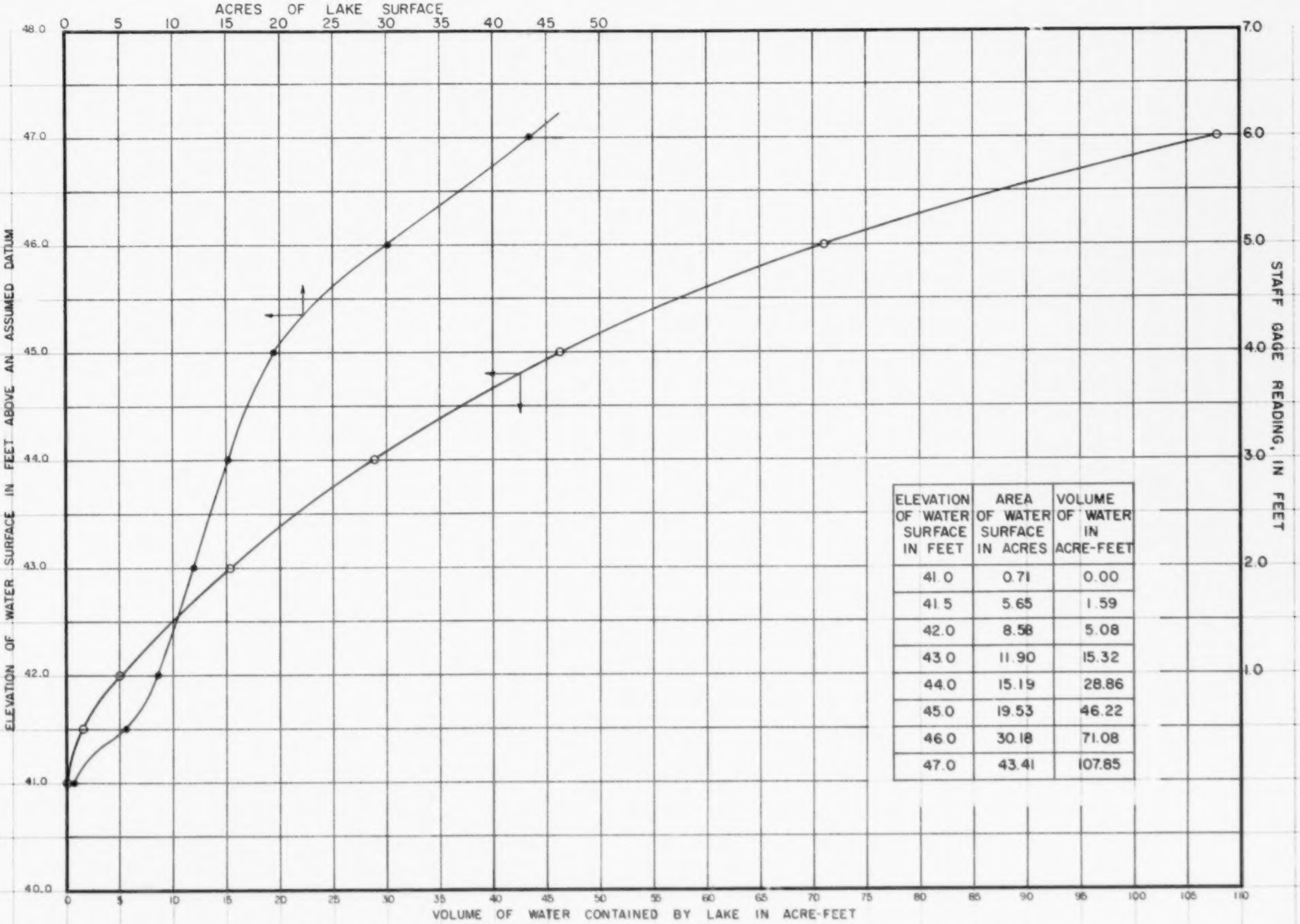
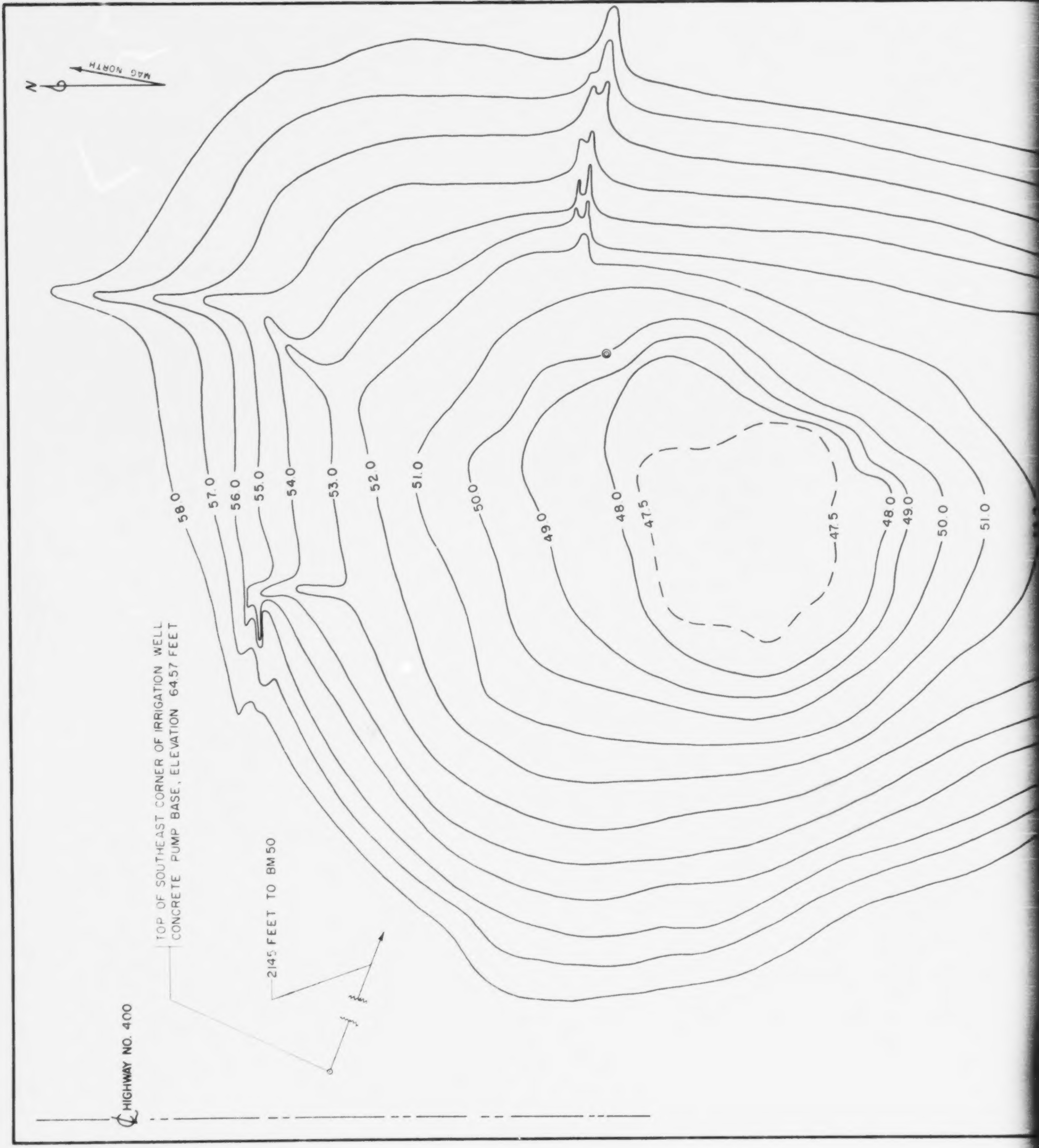


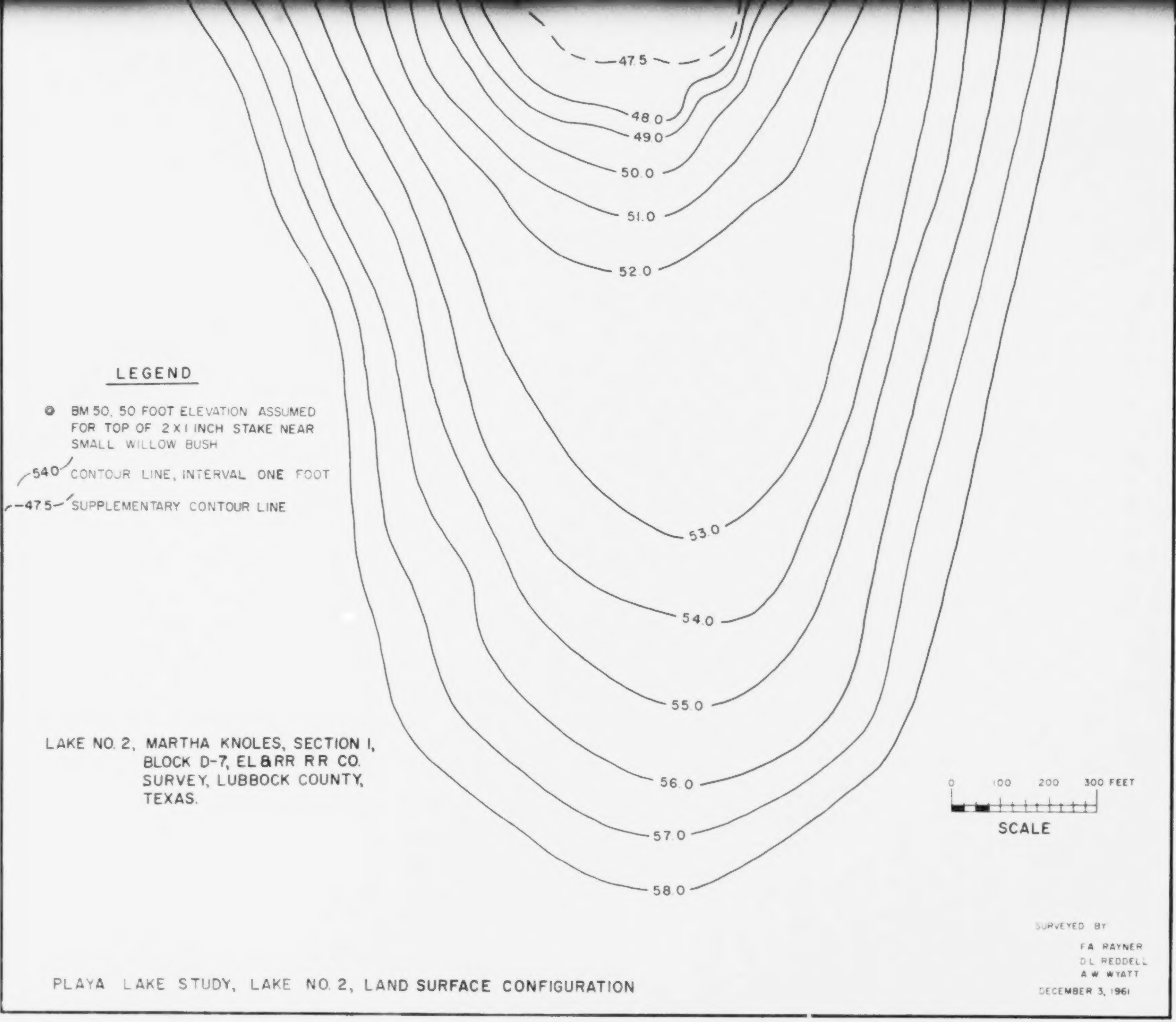
ELEVATION OF WATER SURFACE IN FEET	AREA OF WATER SURFACE IN ACRES	VOLUME OF WATER IN ACRE-FEET
41.0	0.71	0.00
41.5	5.65	1.59
42.0	8.58	5.08
43.0	11.90	15.32
44.0	15.19	28.86
45.0	19.53	46.22
46.0	30.18	71.08
47.0	43.41	107.85

AREA-VOLUME-ELEVATION CURVES FOR LAKE NO.1 LOCATED IN THE NE 1/4 OF SECTION 26, BLOCK 20, H.E. & W.T. R.R. CO. SURVEY, LUBBOCK COUNTY, TEXAS

DRAWN BY D.L. REDDELL
DATE DECEMBER 4, 1961
FROM DATA OBTAINED BY:
F.A. RAYNER
D.L. REDDELL

A


MAG NORTH
N
58.0
57.0
56.0
55.0
54.0
53.0
52.0
51.0
50.0
49.0
48.0
47.5
47.5
48.0
49.0
50.0
51.0
TOP OF SOUTHEAST CORNER OF IRRIGATION WELL
CONCRETE PUMP BASE, ELEVATION 64.57 FEET
2145 FEET TO BM50
℄ HIGHWAY NO. 400


47.5
48.0
49.0
50.0
51.0
52.0
53.0
54.0
55.0
56.0
57.0
58.0
0
100
200
300 FEET
SCALE

LEGEND

● BM 50, 50 FOOT ELEVATION ASSUMED FOR TOP OF 2 X 1 INCH STAKE NEAR SMALL WILLOW BUSH

540 CONTOUR LINE, INTERVAL ONE FOOT

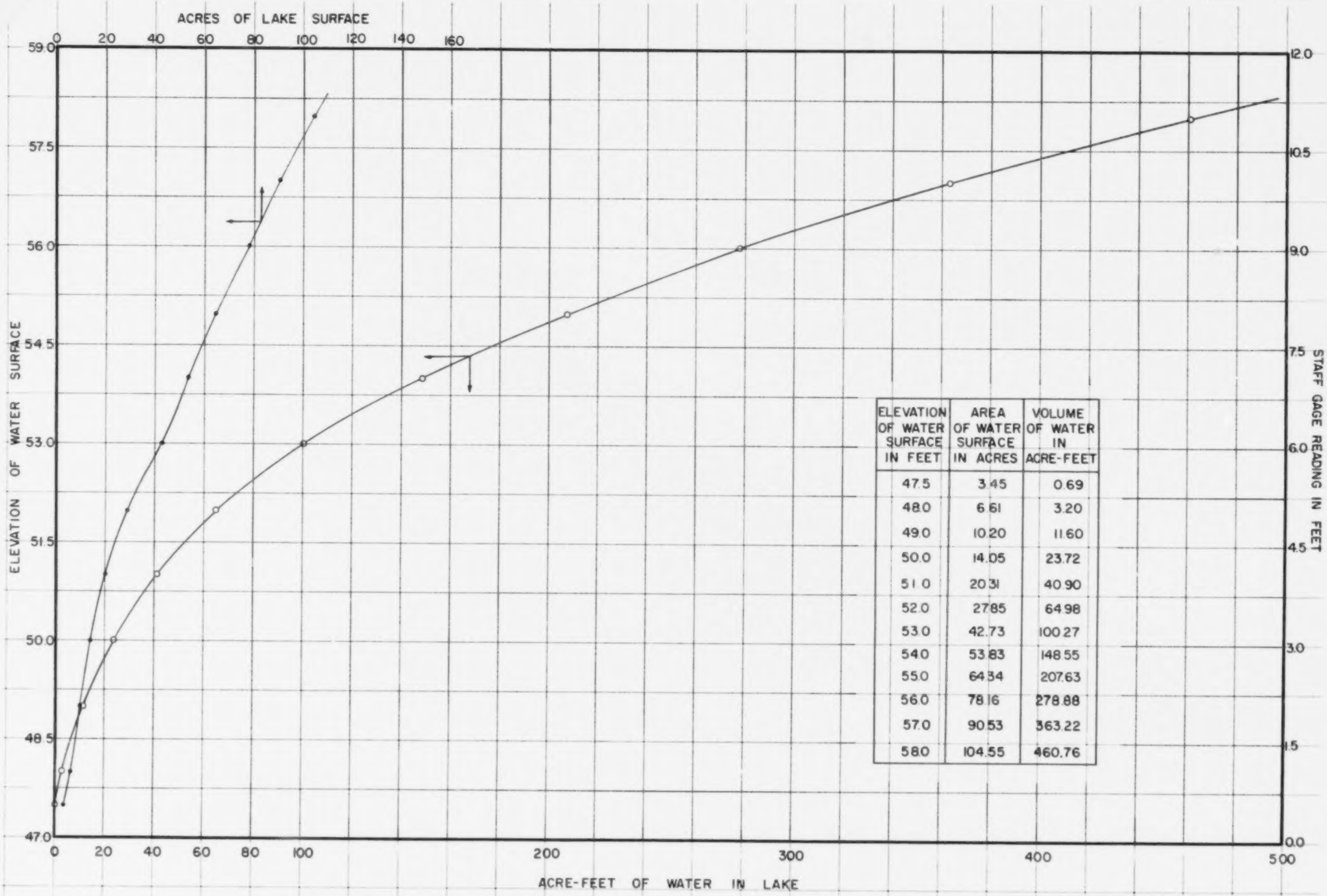
47.5 SUPPLEMENTARY CONTOUR LINE

LAKE NO. 2, MARTHA KNOLES, SECTION 1,
BLOCK D-7, EL&RR RR CO.
SURVEY, LUBBOCK COUNTY,
TEXAS.

SURVEYED BY
F.A. RAYNER
D.L. REDDELL
A.W. WYATT
DECEMBER 3, 1961

PLAYA LAKE STUDY, LAKE NO. 2, LAND SURFACE CONFIGURATION

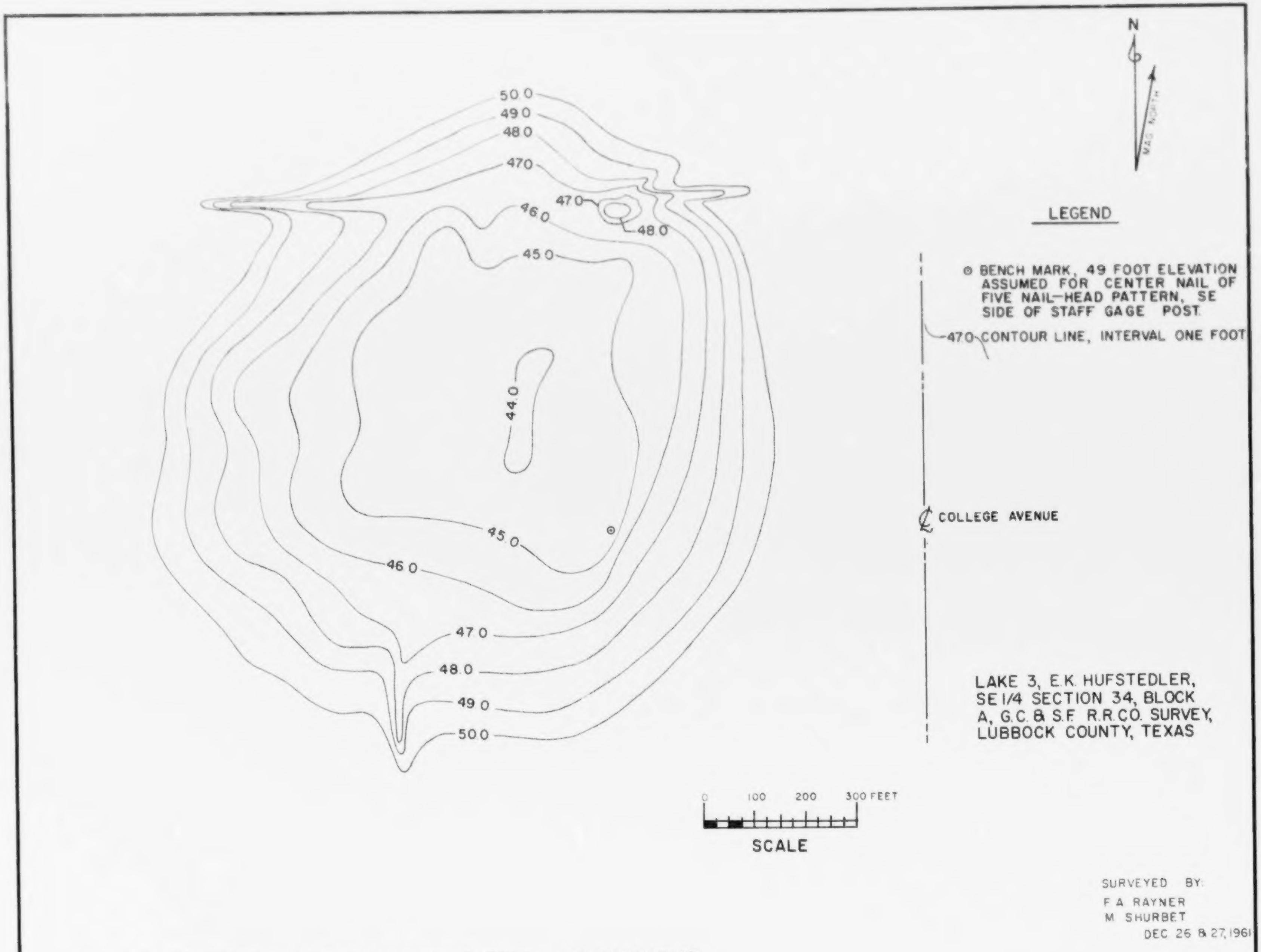
B



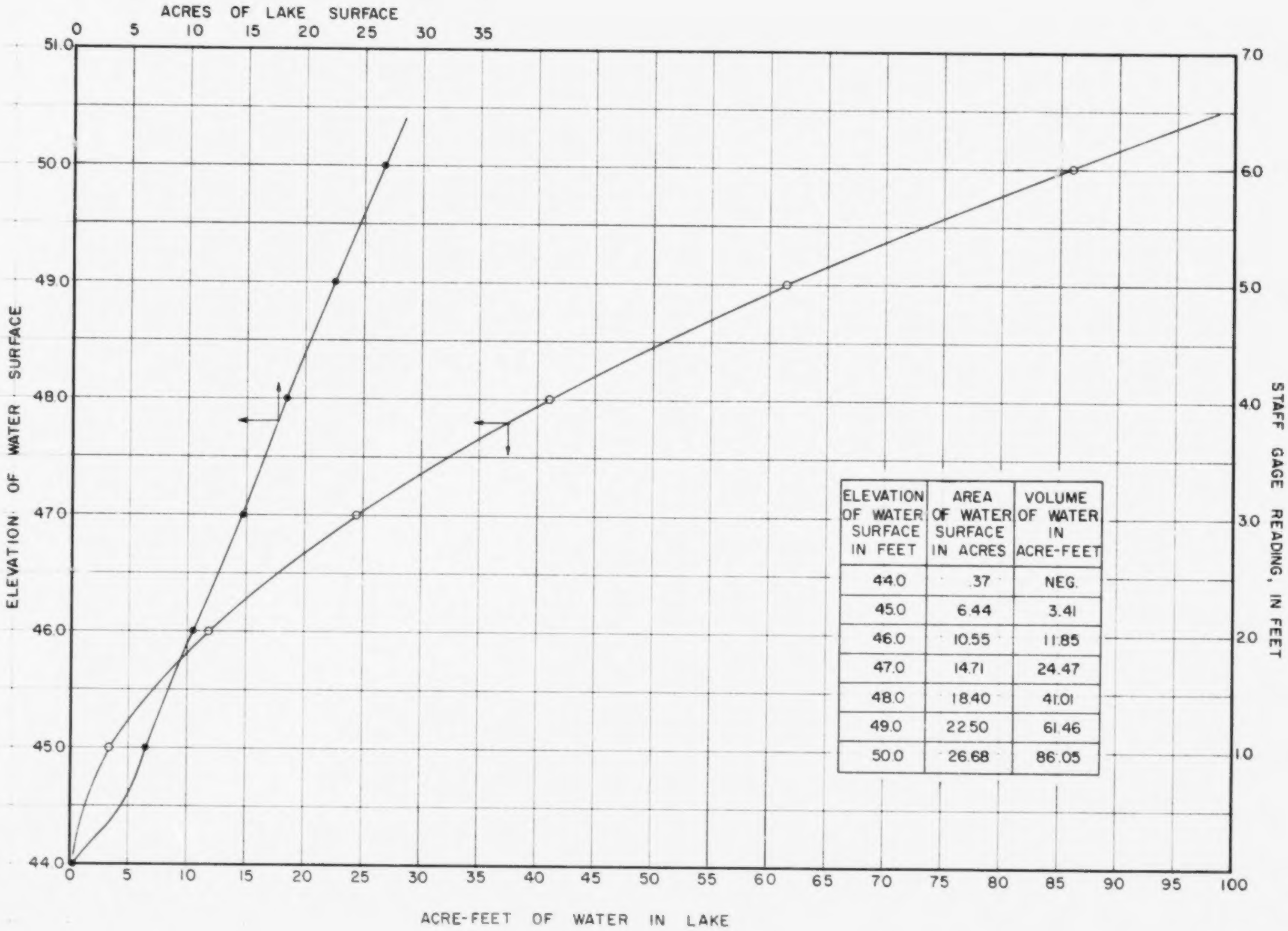
ELEVATION OF WATER SURFACE IN FEET	AREA OF WATER SURFACE IN ACRES	VOLUME OF WATER IN ACRE-FEET
47.5	3.45	0.69
48.0	6.61	3.20
49.0	10.20	11.60
50.0	14.05	23.72
51.0	20.31	40.90
52.0	27.85	64.98
53.0	42.73	100.27
54.0	53.83	148.55
55.0	64.34	207.63
56.0	78.16	278.88
57.0	90.53	363.22
58.0	104.55	460.76

VOLUME-SURFACE AREA-ELEVATION CURVES, LAKE NO. 2, LOCATED IN SECTION 1,
BLOCK D-7, EL & RR RR. CO. SURVEY, LUBBOCK CO., TEXAS

DRAWN BY
F.A. RAYNER
FEB 4, 1962

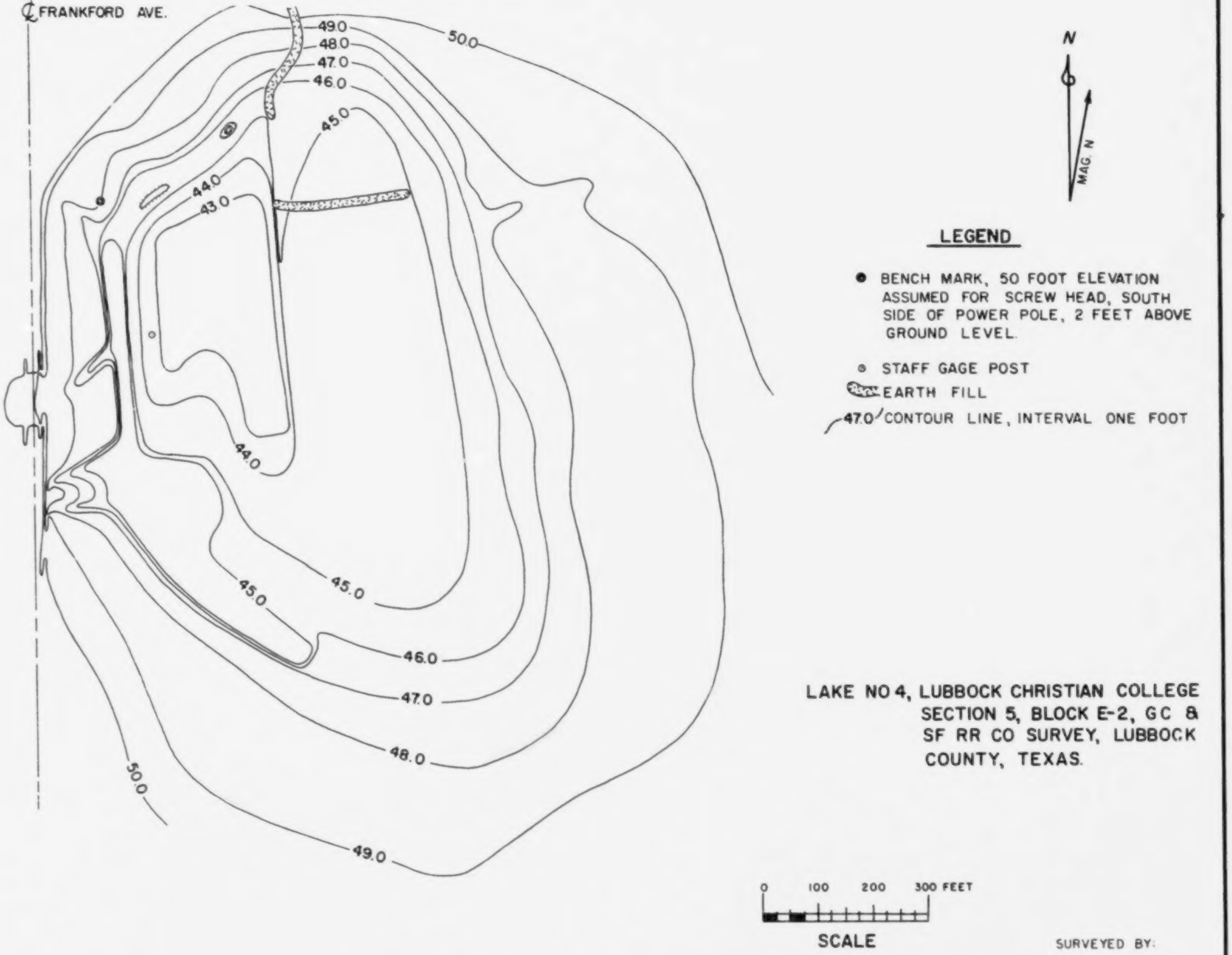

N
MAG. NORTH
LEGEND
⊙ BENCH MARK, 49 FOOT ELEVATION ASSUMED FOR CENTER NAIL OF FIVE NAIL—HEAD PATTERN, SE SIDE OF STAFF GAGE POST.
47.0 CONTOUR LINE, INTERVAL ONE FOOT
℄ COLLEGE AVENUE
LAKE 3, E.K. HUFSTEDLER, SE 1/4 SECTION 34, BLOCK A, G.C. & S.F. R.R.CO. SURVEY, LUBBOCK COUNTY, TEXAS
0
100
200
300 FEET
SCALE
SURVEYED BY:
F.A. RAYNER
M. SHURBET
DEC 26 & 27, 1961
50.0
49.0
48.0
47.0
47.0
48.0
46.0
45.0
44.0
45.0
46.0
47.0
48.0
49.0
50.0

PLAYA LAKE STUDY, LAKE NO. 3, LAND SURFACE CONFIGURATION



ELEVATION OF WATER SURFACE IN FEET	AREA OF WATER SURFACE IN ACRES	VOLUME OF WATER IN ACRE-FEET
44.0	.37	NEG.
45.0	6.44	3.41
46.0	10.55	11.85
47.0	14.71	24.47
48.0	18.40	41.01
49.0	22.50	61.46
50.0	26.68	86.05

AREA-VOLUME-ELEVATION CURVES FOR LAKE NO 3, LOCATED IN SE 1/4 OF SECTION 38, BLOCK A, GC & SF RR CO SURVEY, LUBBOCK COUNTY, TEXAS


℄ FRANKFORD AVE.
50.0
49.0
48.0
47.0
46.0
45.0
44.0
43.0
44.0
45.0
45.0
46.0
47.0
48.0
50.0
49.0
N
MAG. N
0
100
200
300 FEET
SCALE

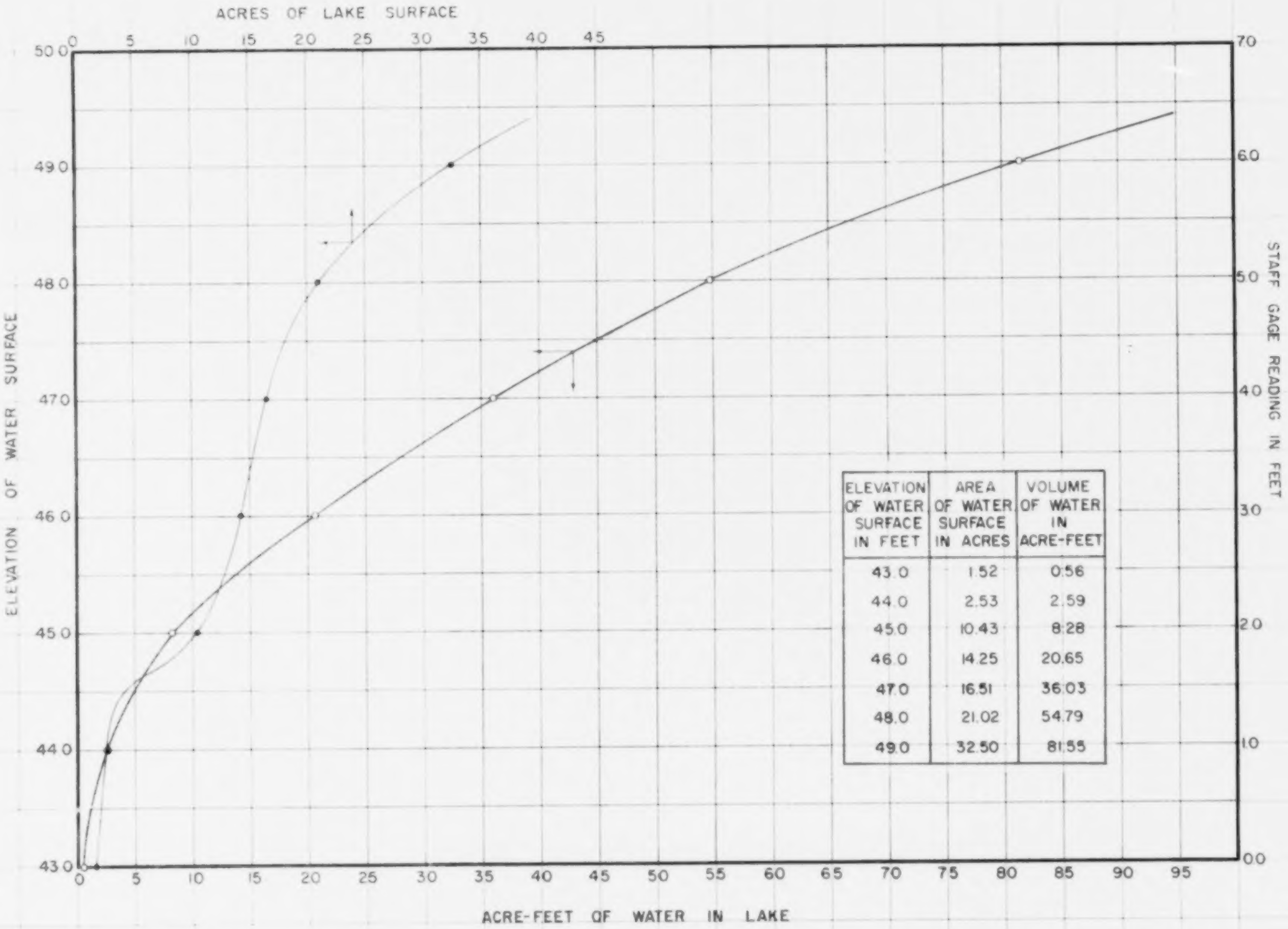
LEGEND

- ● BENCH MARK, 50 FOOT ELEVATION ASSUMED FOR SCREW HEAD, SOUTH SIDE OF POWER POLE, 2 FEET ABOVE GROUND LEVEL.
- ◎ STAFF GAGE POST
- ▨ EARTH FILL
- 47.0 CONTOUR LINE, INTERVAL ONE FOOT

LAKE NO 4, LUBBOCK CHRISTIAN COLLEGE
SECTION 5, BLOCK E-2, GC &
SF RR CO SURVEY, LUBBOCK
COUNTY, TEXAS.

SURVEYED BY:
F.A. RAYNER
M. SHURBET
FEB 4, 1962

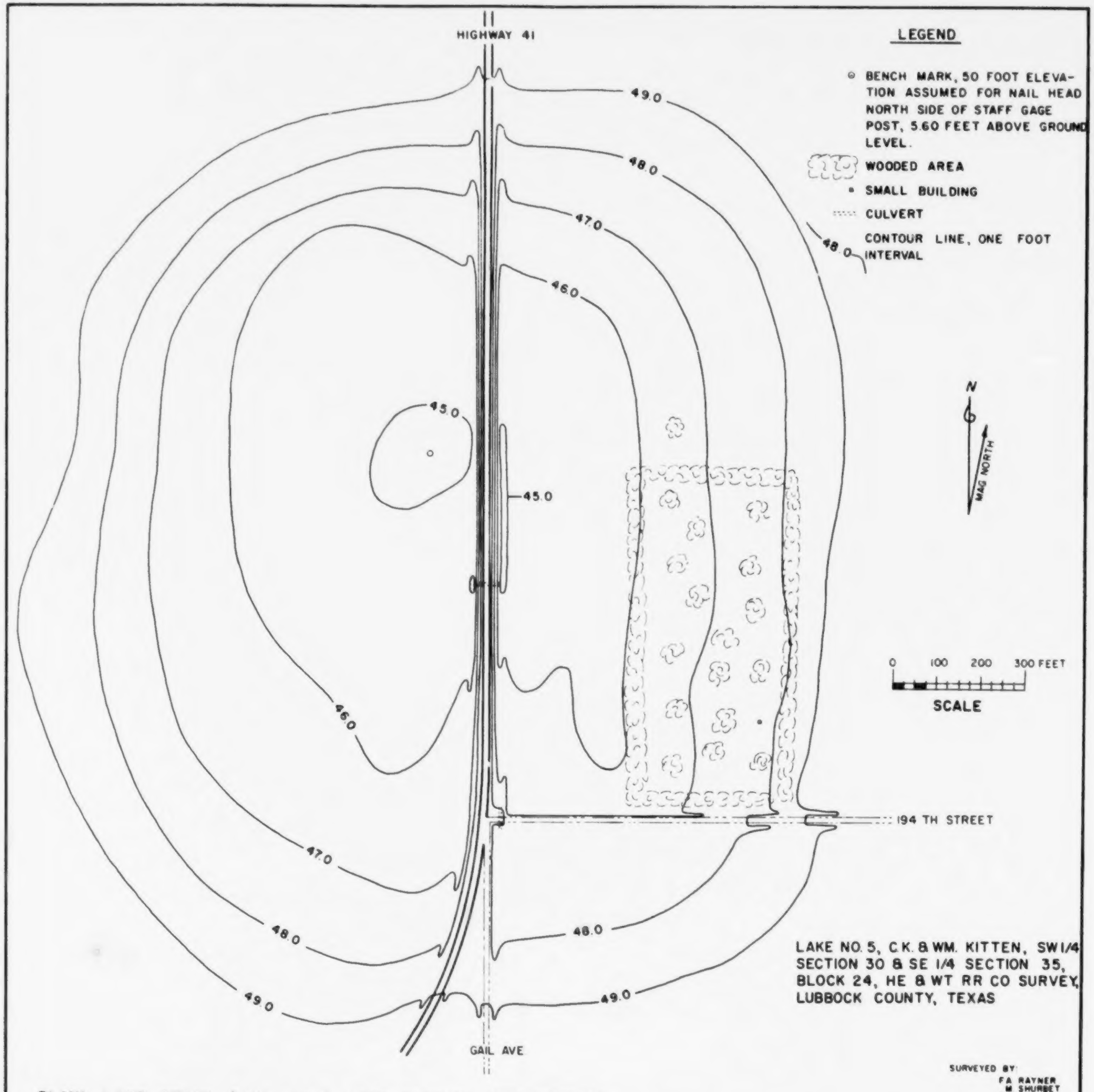
PLAYA LAKE STUDY, LAKE NO. 4, LAND SURFACE CONFIGURATION



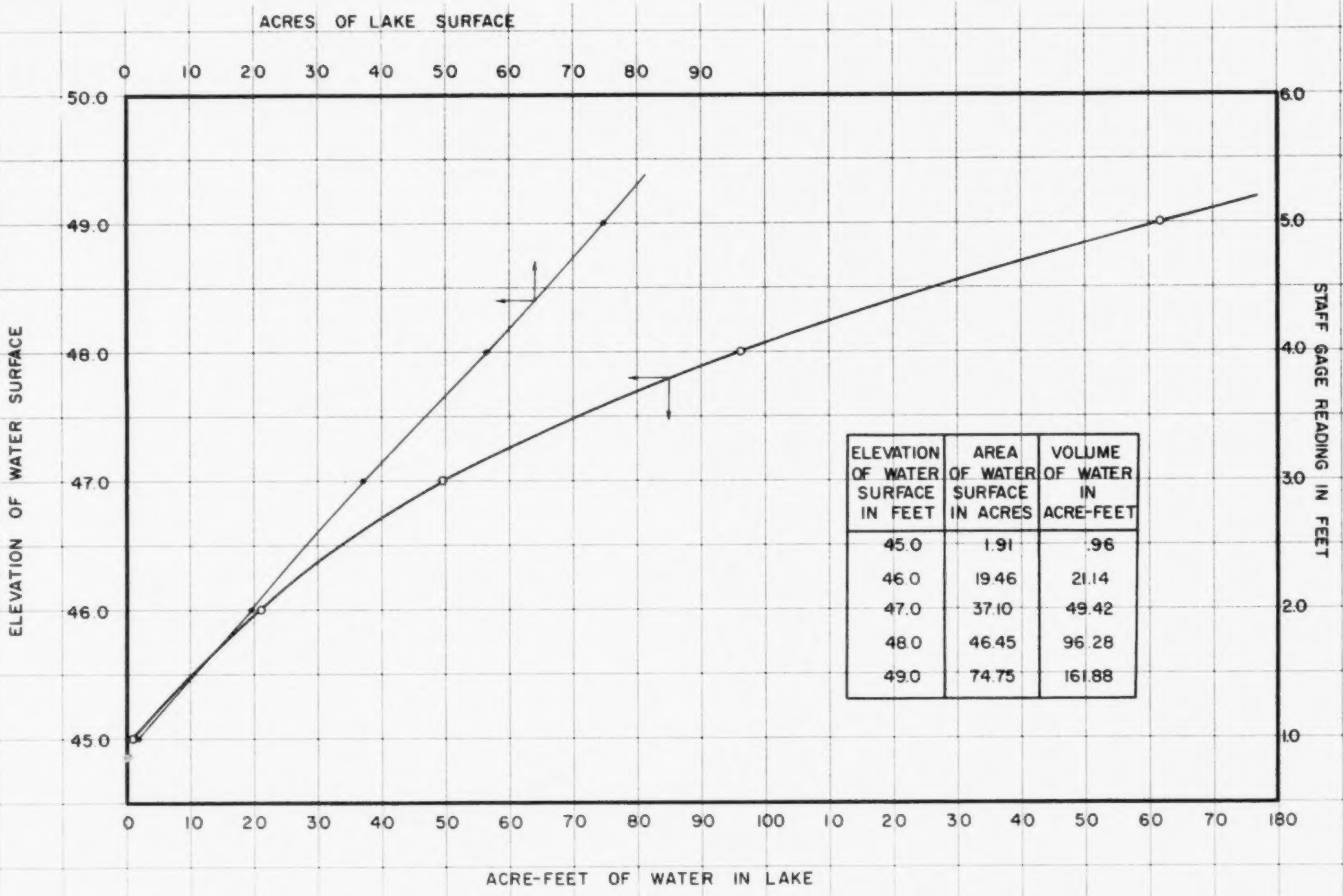
ELEVATION OF WATER SURFACE IN FEET	AREA OF WATER SURFACE IN ACRES	VOLUME OF WATER IN ACRE-FEET
43.0	1.52	0.56
44.0	2.53	2.59
45.0	10.43	8.28
46.0	14.25	20.65
47.0	16.51	36.03
48.0	21.02	54.79
49.0	32.50	81.55

ELEVATION-VOLUME AND AREA CURVES, FOR LAKE NO. 4, IN SECTION 5,
BLOCK E-2, GC & SF RR CO. SURVEY, LUBBOCK COUNTY, TEXAS.

DRAWN BY
F.A. RAYNER
FEB 11, 1962


HIGHWAY 41
LEGEND
BENCH MARK, 50 FOOT ELEVATION ASSUMED FOR NAIL HEAD NORTH SIDE OF STAFF GAGE POST, 5.60 FEET ABOVE GROUND LEVEL.
WOODED AREA
SMALL BUILDING
CULVERT
CONTOUR LINE, ONE FOOT INTERVAL
48.0
49.0
48.0
47.0
46.0
45.0
45.0
46.0
47.0
48.0
49.0
48.0
49.0
N
MAG NORTH
0 100 200 300 FEET
SCALE
194 TH STREET
GAIL AVE
LAKE NO. 5, C.K. & WM. KITTEN, SW 1/4 SECTION 30 & SE 1/4 SECTION 35, BLOCK 24, HE & WT RR CO SURVEY, LUBBOCK COUNTY, TEXAS
SURVEYED BY:
F.A. RAYNER
M. SHURBET
A.W. WYATT
FEBRUARY 10, 1962

PLAYA LAKE STUDY, LAKE NO. 5, LAND SURFACE CONFIGURATION

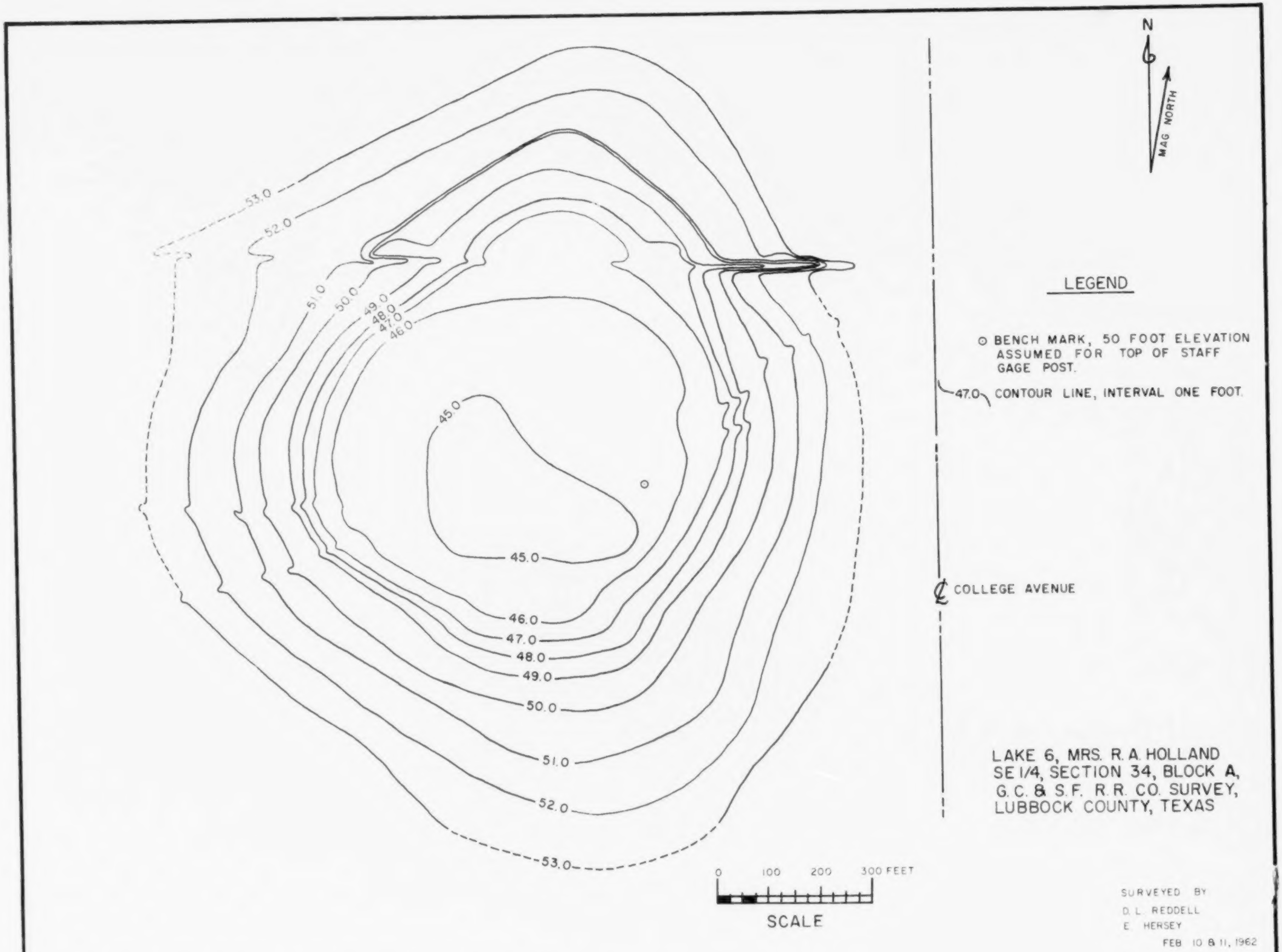


ELEVATION OF WATER SURFACE IN FEET	AREA OF WATER SURFACE IN ACRES	VOLUME OF WATER IN ACRE-FEET
45.0	1.91	.96
46.0	19.46	21.14
47.0	37.10	49.42
48.0	46.45	96.28
49.0	74.75	161.88

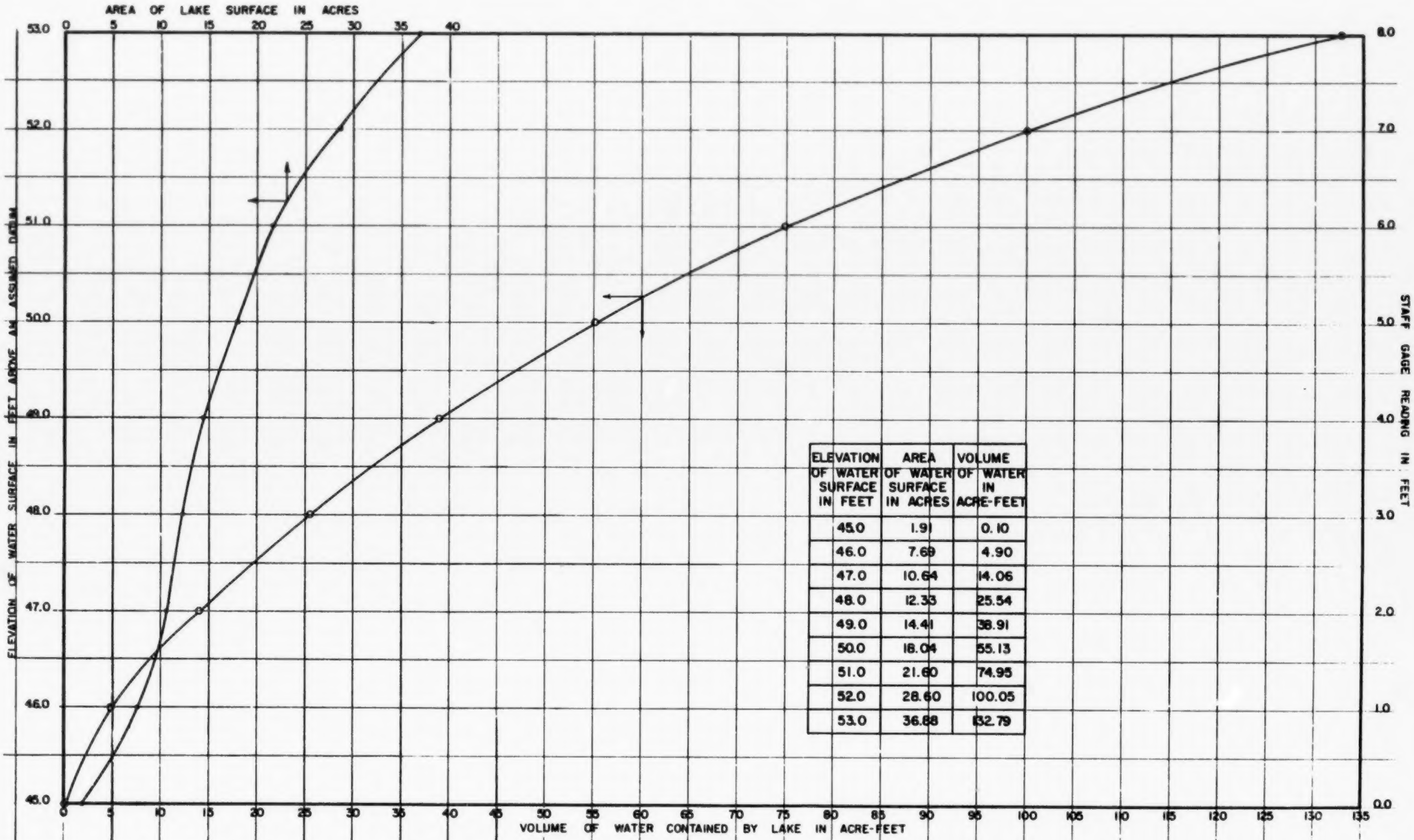
ELEVATION-AREA & ELEVATION-VOLUME CURVES, LAKE NO. 5, IN THE SW 1/4 SECTION 30 & SE 1/4 SECTION 35, BLOCK 24, HE & WT RR CO SURVEY, LUBBOCK COUNTY, TEXAS.

DRAWN BY:
F.A. RAYNER

APRIL 22, 1960


N
MAG NORTH
LEGEND
⊙ BENCH MARK, 50 FOOT ELEVATION ASSUMED FOR TOP OF STAFF GAGE POST.
47.0 CONTOUR LINE, INTERVAL ONE FOOT.
℄ COLLEGE AVENUE
LAKE 6, MRS. R. A. HOLLAND
SE 1/4, SECTION 34, BLOCK A,
G. C. & S. F. R. R. CO. SURVEY,
LUBBOCK COUNTY, TEXAS
SURVEYED BY
D. L. REDDELL
E. HERSEY
FEB 10 & 11, 1962
0
100
200
300 FEET
SCALE
45.0
45.0
46.0
47.0
48.0
49.0
50.0
51.0
52.0
53.0
46.0
47.0
48.0
49.0
50.0
51.0
52.0
53.0

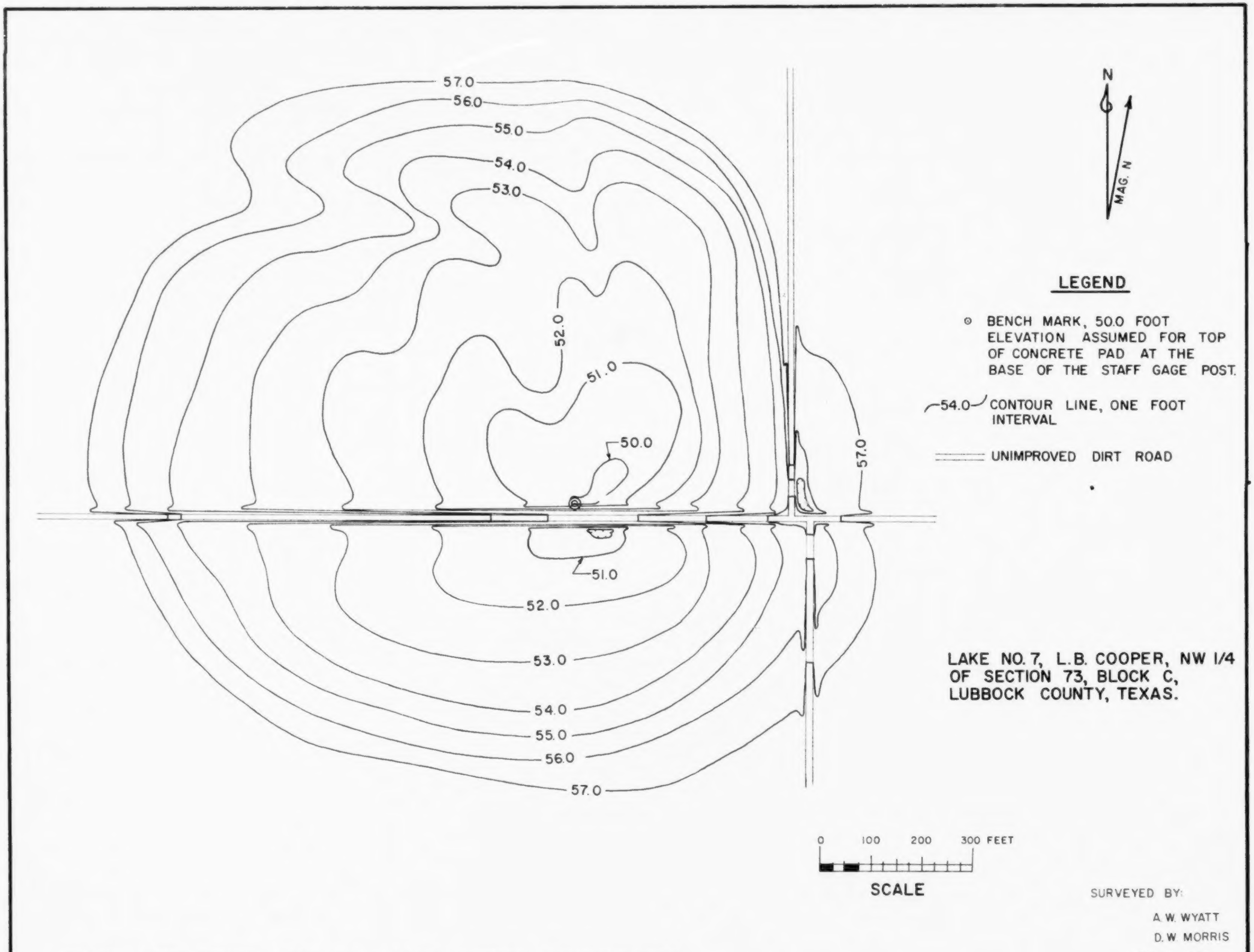
PLAYA LAKE STUDY, LAKE NO. 6, LAND SURFACE CONFIGURATION



ELEVATION OF WATER SURFACE IN FEET	AREA OF WATER SURFACE IN ACRES	VOLUME OF WATER IN ACRE-FEET
45.0	1.91	0.10
46.0	7.69	4.90
47.0	10.64	14.06
48.0	12.33	25.54
49.0	14.41	38.91
50.0	18.04	55.13
51.0	21.60	74.95
52.0	28.60	100.05
53.0	36.88	132.79

VOLUME-ELEVATION AND AREA-ELEVATION CURVES FOR LAKE NO.6 LOCATED IN THE SE 1/4 OF SECTION 34,
BLOCK A, G.C. & S.F. R.R. CO. SURVEY, LUBBOCK COUNTY, TEXAS

DRAWN BY: D. L. REDDELL
DATE: MAY 8, 1962


57.0
56.0
55.0
54.0
53.0
52.0
51.0
50.0
51.0
52.0
53.0
54.0
55.0
56.0
57.0
57.0
N
MAG. N
0 100 200 300 FEET
SCALE

LEGEND

⊙ BENCH MARK, 50.0 FOOT ELEVATION ASSUMED FOR TOP OF CONCRETE PAD AT THE BASE OF THE STAFF GAGE POST.

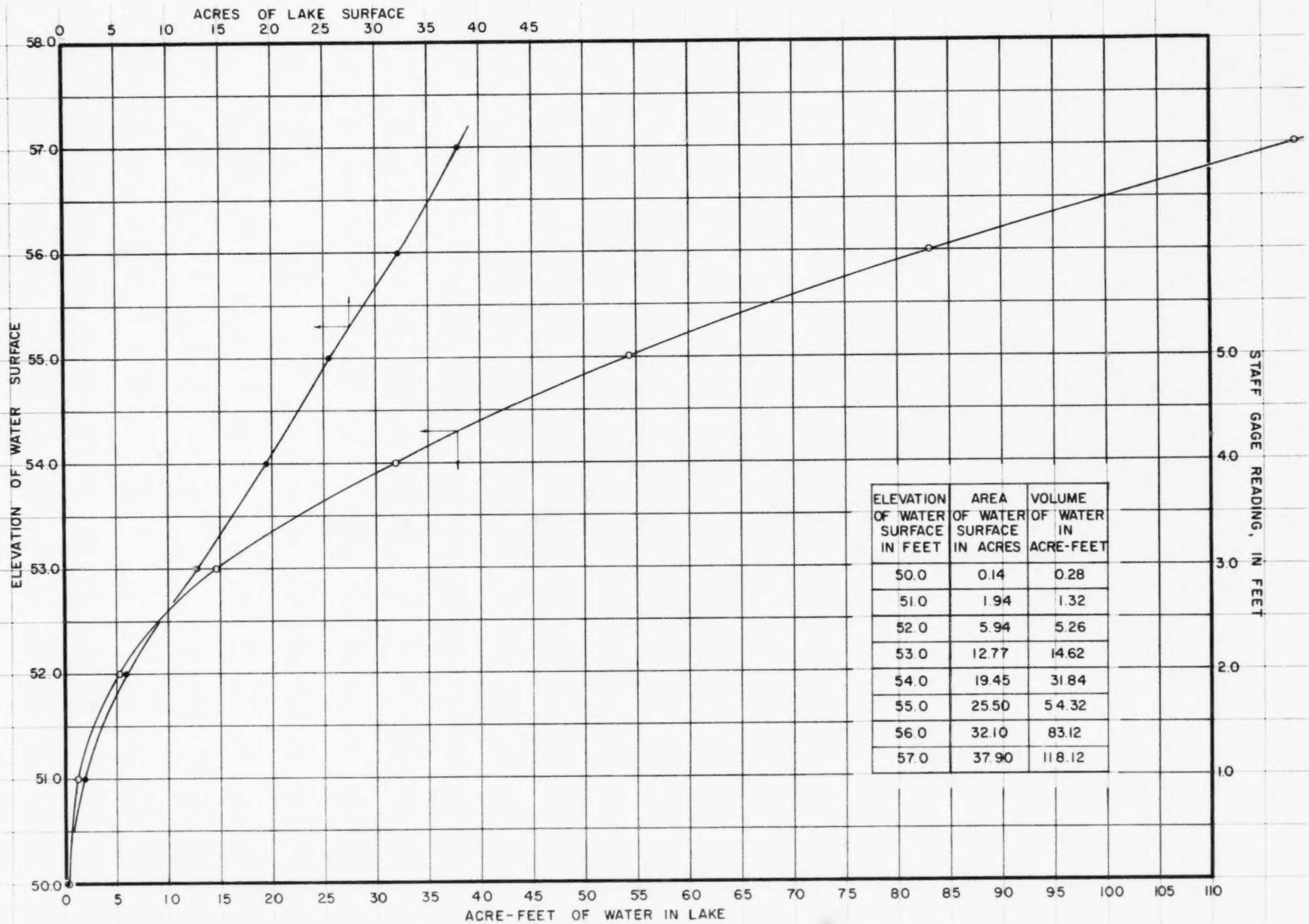
54.0 CONTOUR LINE, ONE FOOT INTERVAL

UNIMPROVED DIRT ROAD

LAKE NO. 7, L.B. COOPER, NW 1/4
OF SECTION 73, BLOCK C,
LUBBOCK COUNTY, TEXAS.

SURVEYED BY:
A. W. WYATT
D. W. MORRIS
FEB. 10, 1962

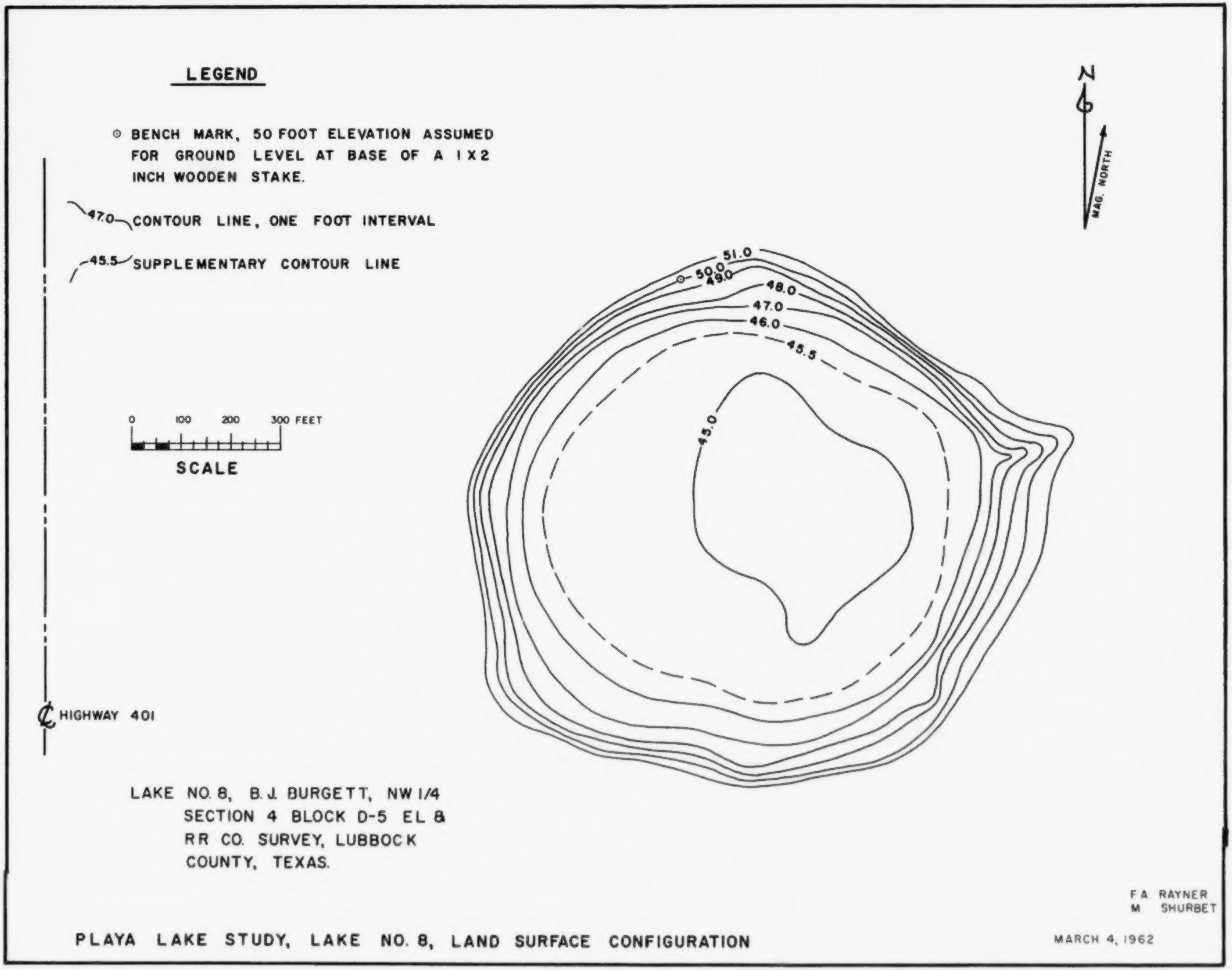
PLAYA LAKE STUDY, LAKE NO. 7, LAND SURFACE CONFIGURATION



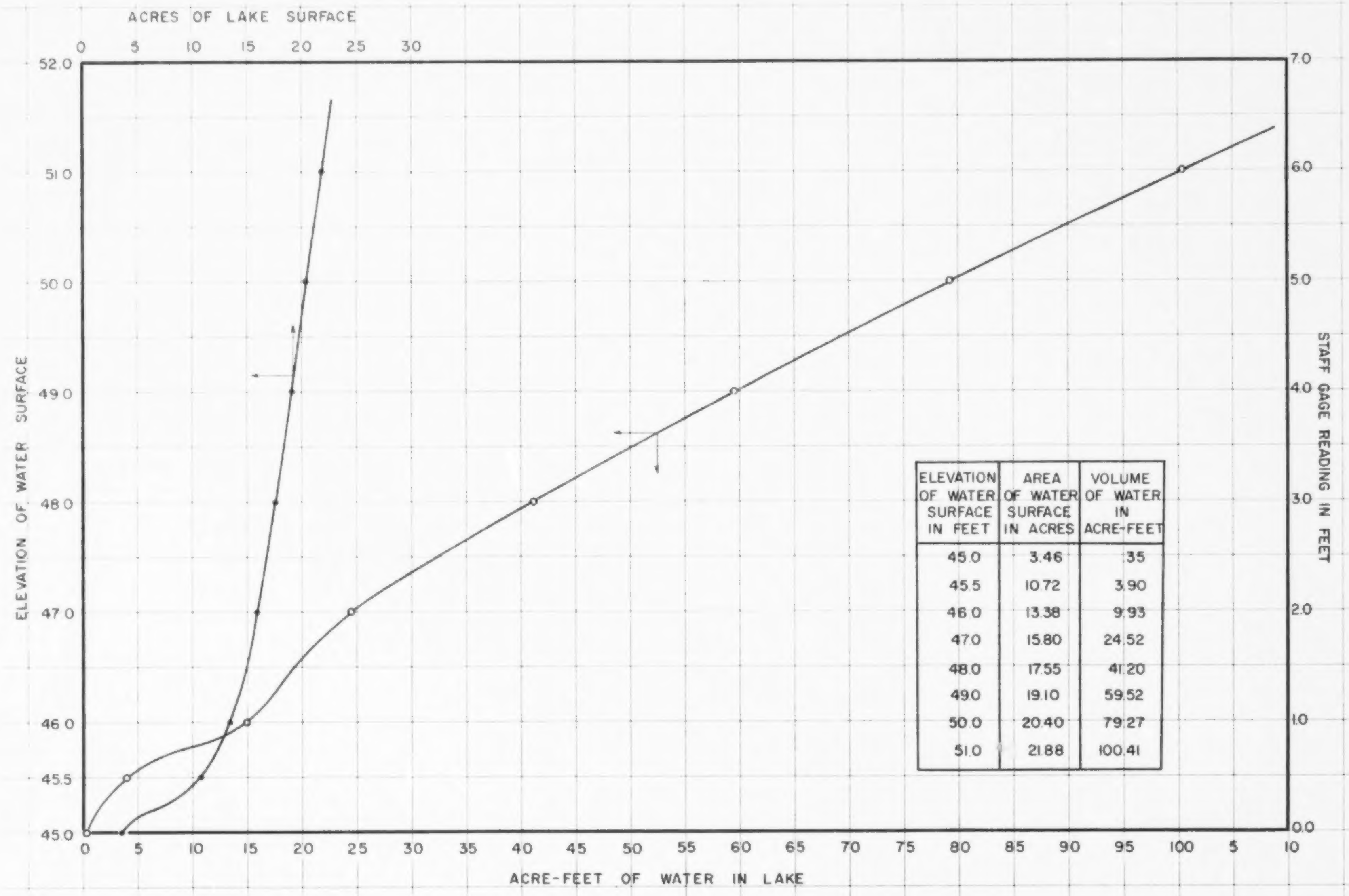
ELEVATION OF WATER SURFACE IN FEET	AREA OF WATER SURFACE IN ACRES	VOLUME OF WATER IN ACRE-FEET
50.0	0.14	0.28
51.0	1.94	1.32
52.0	5.94	5.26
53.0	12.77	14.62
54.0	19.45	31.84
55.0	25.50	54.32
56.0	32.10	83.12
57.0	37.90	118.12

ELEVATION-AREA & ELEVATION-VOLUME CURVES, LAKE NO. 7, IN THE NW 1/4 SECTION 73, BLOCK C, LUBBOCK COUNTY, TEXAS

DRAWN BY
F.A. RAYNER
SEPT 9, 1961


LEGEND
⊙ BENCH MARK, 50 FOOT ELEVATION ASSUMED FOR GROUND LEVEL AT BASE OF A 1 X 2 INCH WOODEN STAKE.
47.0 CONTOUR LINE, ONE FOOT INTERVAL
45.5 SUPPLEMENTARY CONTOUR LINE
0
100
200
300 FEET
SCALE
℄ HIGHWAY 401
N
MAG. NORTH
51.0
50.0
49.0
48.0
47.0
46.0
45.5
45.0
LAKE NO. 8, B. J. BURGETT, NW 1/4 SECTION 4 BLOCK D-5 EL & RR CO. SURVEY, LUBBOCK COUNTY, TEXAS.
F A RAYNER
M SHURBET
MARCH 4, 1962

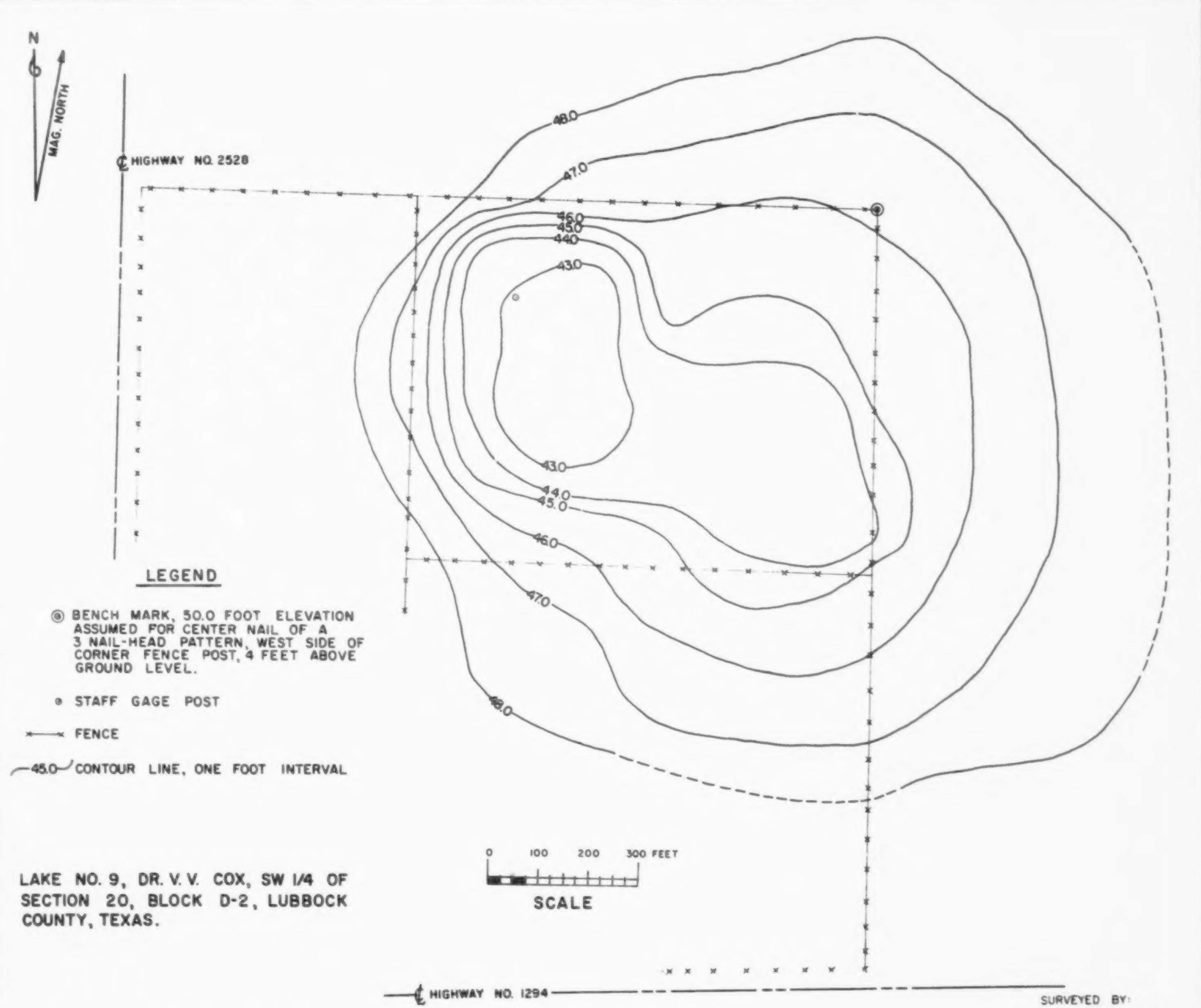
PLAYA LAKE STUDY, LAKE NO. 8, LAND SURFACE CONFIGURATION



ELEVATION OF WATER SURFACE IN FEET	AREA OF WATER SURFACE IN ACRES	VOLUME OF WATER IN ACRE-FEET
45.0	3.46	.35
45.5	10.72	3.90
46.0	13.38	9.93
47.0	15.80	24.52
48.0	17.55	41.20
49.0	19.10	59.52
50.0	20.40	79.27
51.0	21.88	100.41

ELEVATION-AREA & ELEVATION-VOLUME CURVES FOR LAKE NO. 8, IN THE NW 1/4 OF SECTION 4, BLOCK D-5, EL & RR CO SURVEY, LUBBOCK COUNTY, TEXAS.

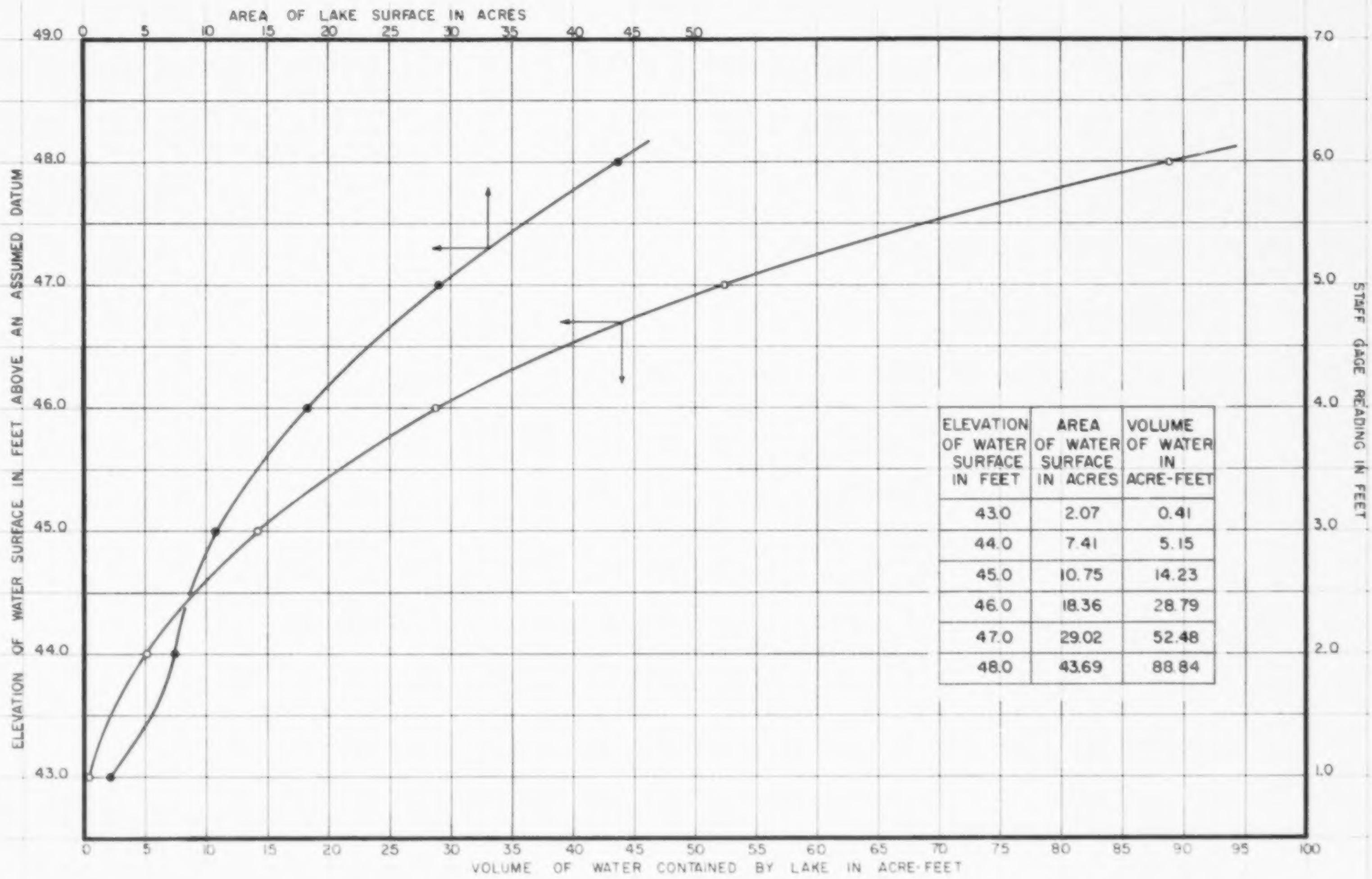
DRAWN BY:
FA RAYNER
APR 22, 1962


N
MAG. NORTH
℄ HIGHWAY NO. 2528
48.0
47.0
46.0
45.0
44.0
43.0
LEGEND
◉ BENCH MARK, 50.0 FOOT ELEVATION ASSUMED FOR CENTER NAIL OF A 3 NAIL-HEAD PATTERN, WEST SIDE OF CORNER FENCE POST, 4 FEET ABOVE GROUND LEVEL.
● STAFF GAGE POST
×—× FENCE
45.0 CONTOUR LINE, ONE FOOT INTERVAL
0
100
200
300 FEET
SCALE
℄ HIGHWAY NO. 1294

LAKE NO. 9, DR. V. V. COX, SW 1/4 OF SECTION 20, BLOCK D-2, LUBBOCK COUNTY, TEXAS.

SURVEYED BY:
D. L. REDDELL
A. L. COX
AUGUST 18, 1962

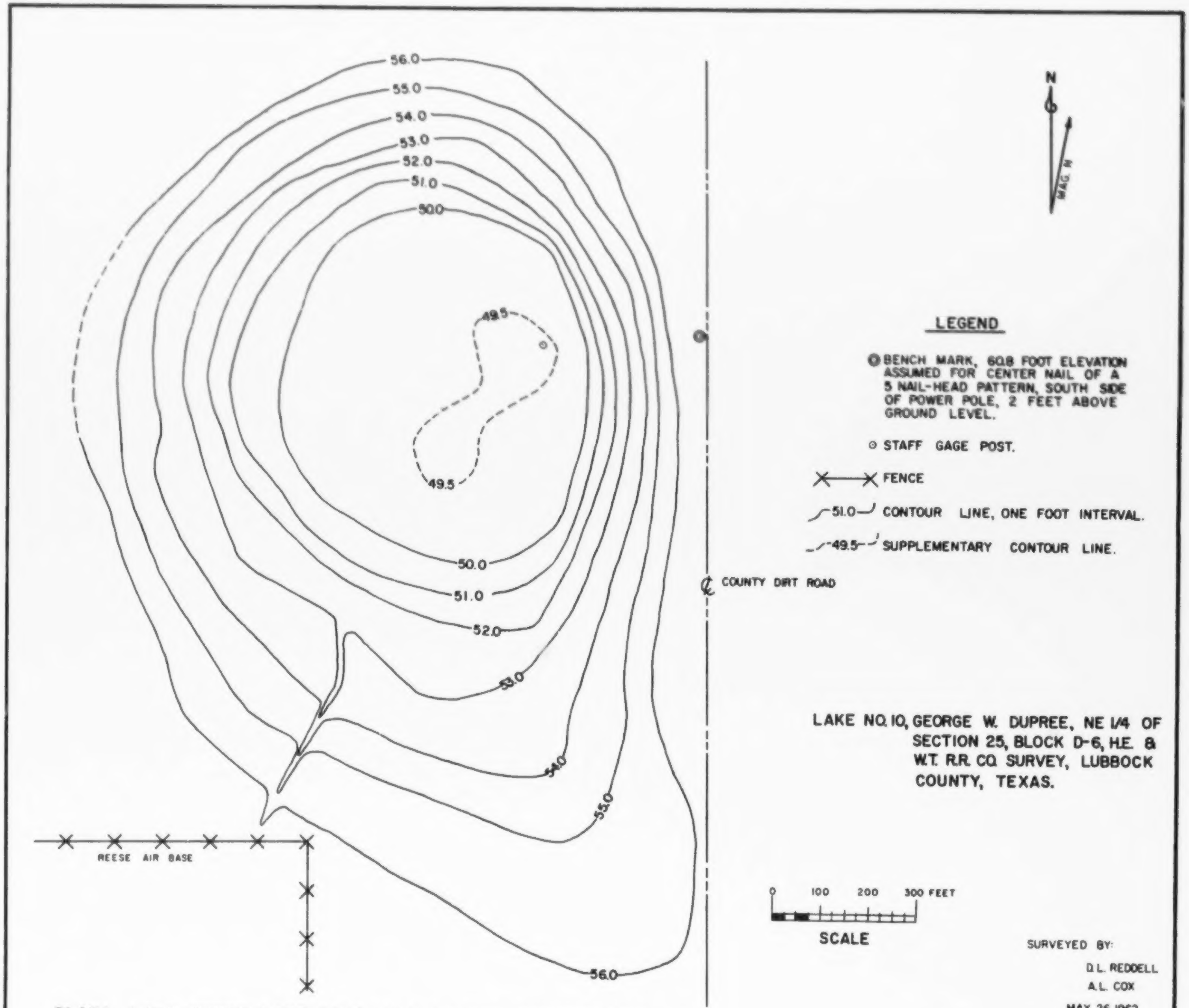
PLAYA LAKE STUDY, LAKE NO. 9, LAND SURFACE CONFIGURATION



ELEVATION OF WATER SURFACE IN FEET	AREA OF WATER SURFACE IN ACRES	VOLUME OF WATER IN ACRE-FEET
43.0	2.07	0.41
44.0	7.41	5.15
45.0	10.75	14.23
46.0	18.36	28.79
47.0	29.02	52.48
48.0	43.69	88.84

VOLUME-ELEVATION AND AREA-ELEVATION CURVES FOR LAKE NO.9 LOCATED IN THE SW 1/4 OF SECTION 20, BLOCK D-2, LUBBOCK COUNTY, TEXAS.

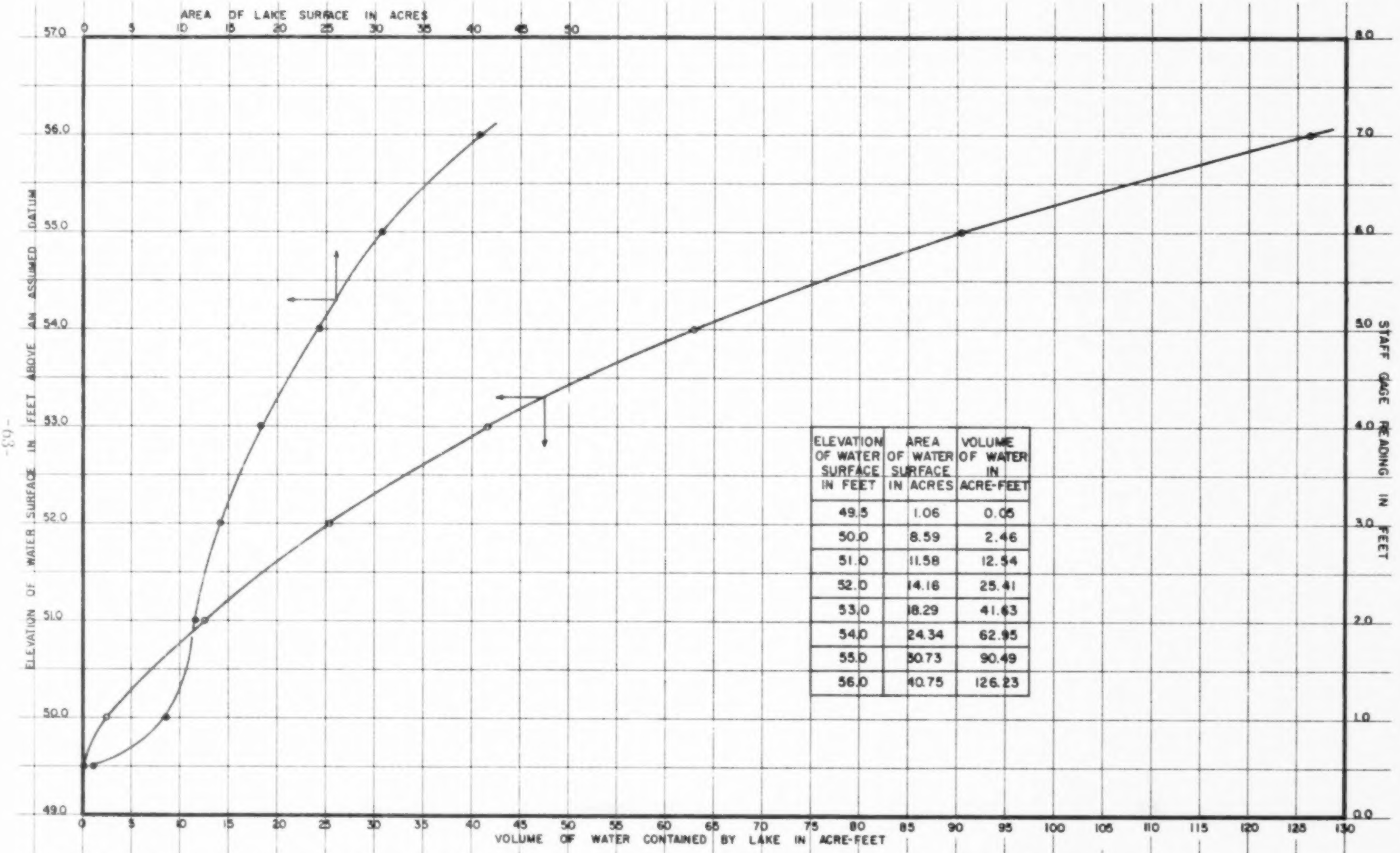
DRAWN BY D. L. REDDELL
DATE SEPTEMBER [illegible]


56.0
55.0
54.0
53.0
52.0
51.0
50.0
49.5
49.5
50.0
51.0
52.0
53.0
54.0
55.0
56.0
REESE AIR BASE
COUNTY DIRT ROAD
N
MAG. N
LEGEND
BENCH MARK, 60.8 FOOT ELEVATION ASSUMED FOR CENTER NAIL OF A 5 NAIL-HEAD PATTERN, SOUTH SIDE OF POWER POLE, 2 FEET ABOVE GROUND LEVEL.
STAFF GAGE POST.
FENCE
51.0 CONTOUR LINE, ONE FOOT INTERVAL.
49.5 SUPPLEMENTARY CONTOUR LINE.
0
100
200
300 FEET
SCALE

LAKE NO. 10, GEORGE W. DUPREE, NE 1/4 OF SECTION 25, BLOCK D-6, H.E. & W.T. R.R. CO. SURVEY, LUBBOCK COUNTY, TEXAS.

SURVEYED BY:
D.L. REDDELL
A.L. COX
MAY 26, 1962

PLAYA LAKE STUDY, LAKE NO. 10, LAND SURFACE CONFIGURATION



ELEVATION OF WATER SURFACE IN FEET	AREA OF WATER SURFACE IN ACRES	VOLUME OF WATER IN ACRE-FEET
49.5	1.06	0.05
50.0	8.59	2.46
51.0	11.58	12.54
52.0	14.16	25.41
53.0	18.29	41.63
54.0	24.34	62.95
55.0	30.73	90.49
56.0	40.75	126.23

VOLUME-ELEVATION AND AREA-ELEVATION CURVES FOR LAKE NO. 10 LOCATED IN THE NE 1/4 OF SECTION 25
BLOCK D-6, H.E. & W.T. R.R. CO. SURVEY, LUBBOCK COUNTY, TEXAS

DRAWN BY: D. L. REDDELL
DATE: SEPTEMBER 10, 1962

APPENDIX II. Hydrological Data

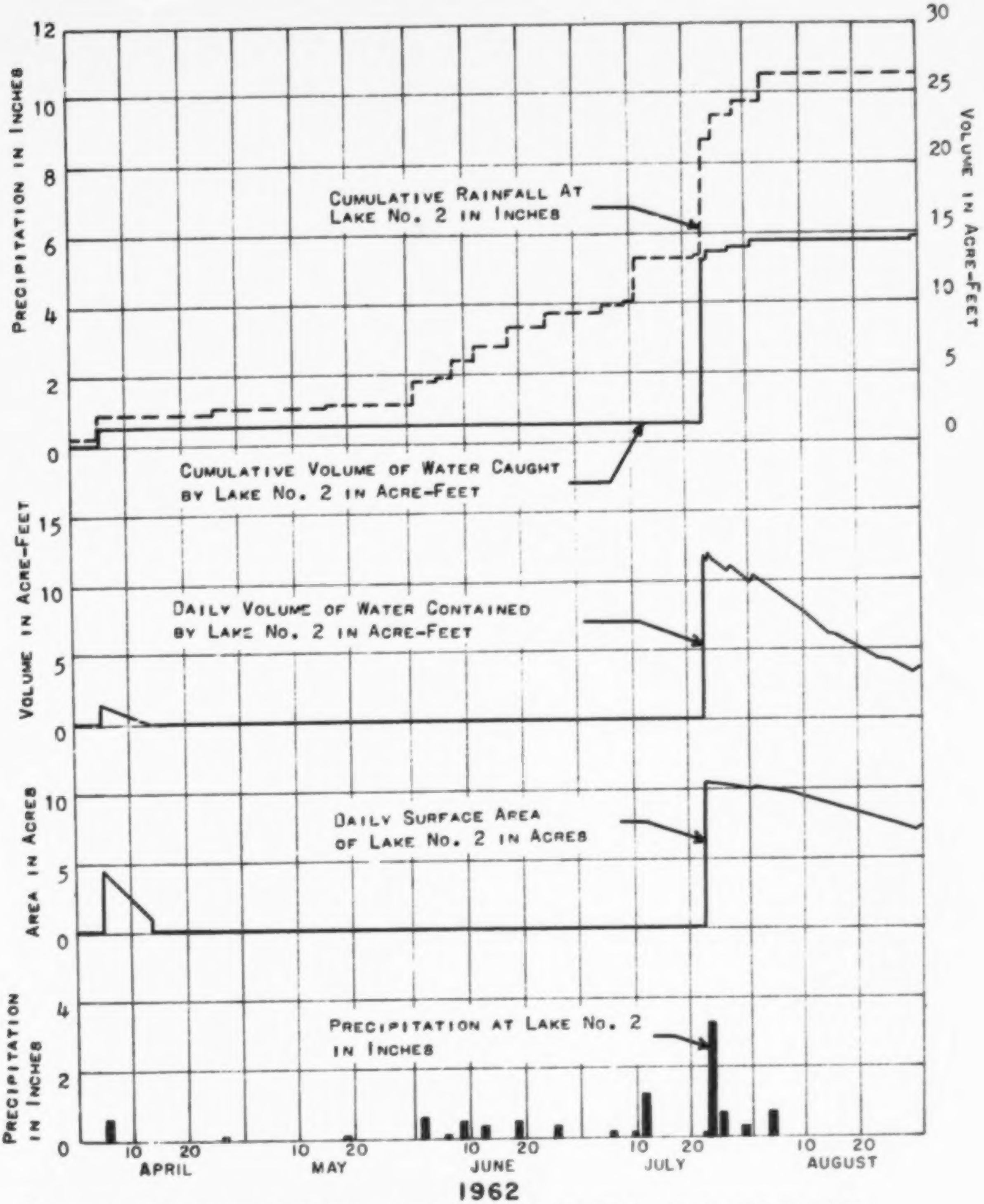


Figure 1. CUMULATIVE RAINFALL, CUMULATIVE VOLUME OF WATER CAUGHT BY LAKE, DAILY VOLUME OF WATER CONTAINED BY LAKE, DAILY SURFACE AREA OF LAKE, AND PRECIPITATION AT LAKE NO. 2 (KNOLES).

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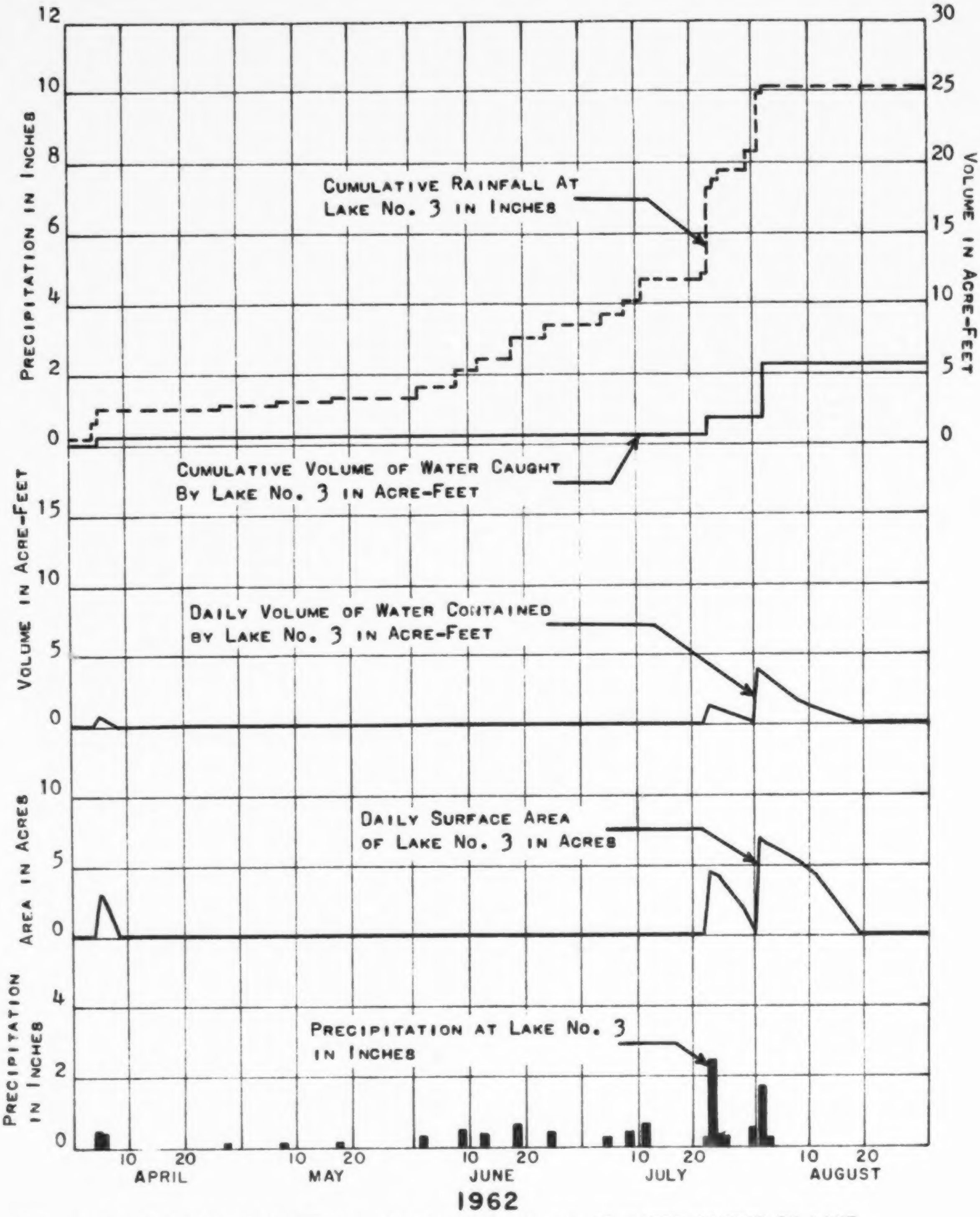

Figure 2. CUMULATIVE RAINFALL, CUMULATIVE VOLUME OF WATER CAUGHT BY LAKE, DAILY VOLUME OF WATER CONTAINED BY LAKE, DAILY SURFACE AREA OF LAKE, AND PRECIPITATION AT LAKE NO. 3 (HUFSTEDLER).

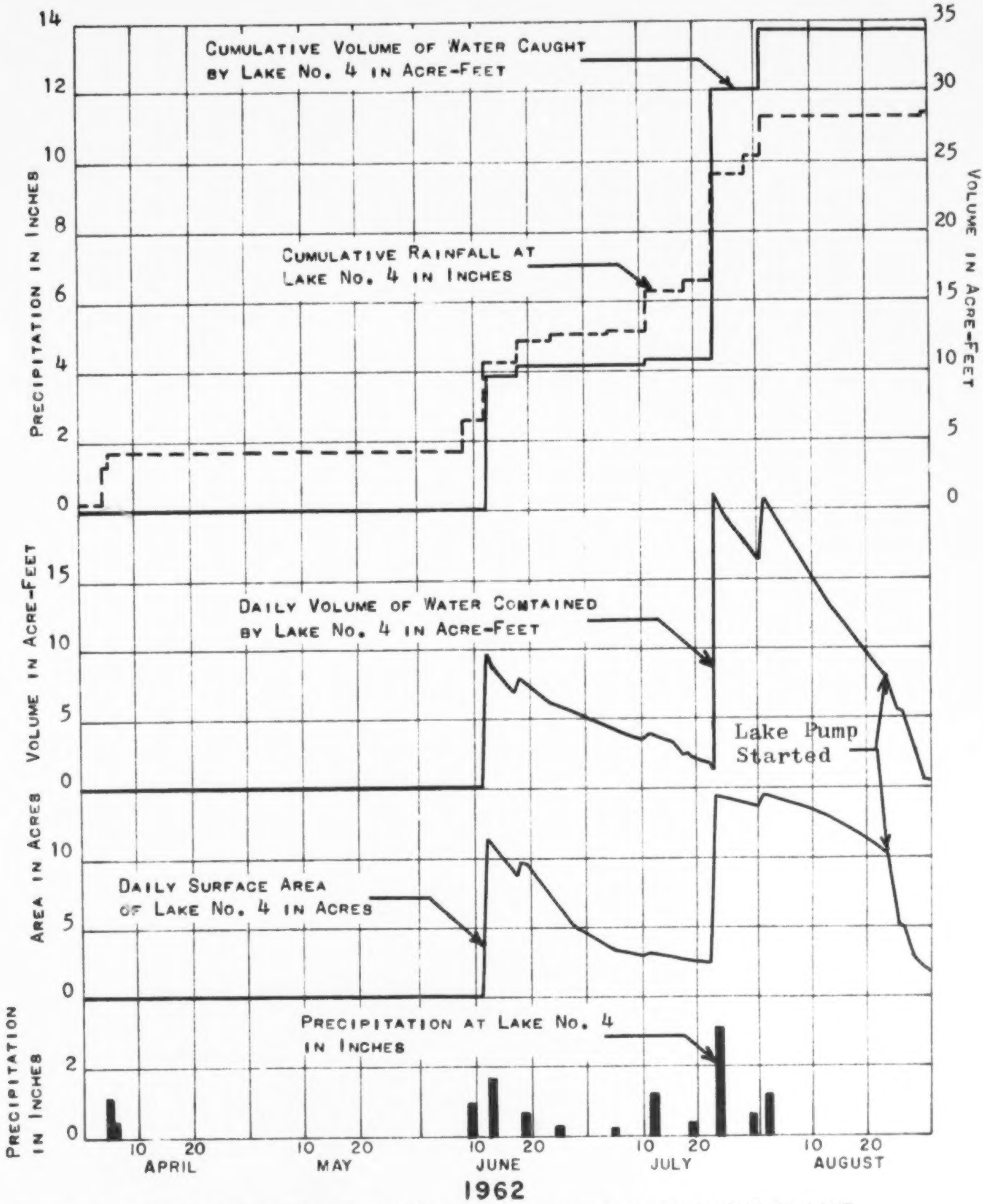

Figure 3. CUMULATIVE RAINFALL, CUMULATIVE VOLUME OF WATER CAUGHT BY LAKE, DAILY VOLUME OF WATER CONTAINED BY LAKE, DAILY SURFACE AREA OF LAKE, AND PRECIPITATION AT LAKE NO. 4 (L.C.C.).

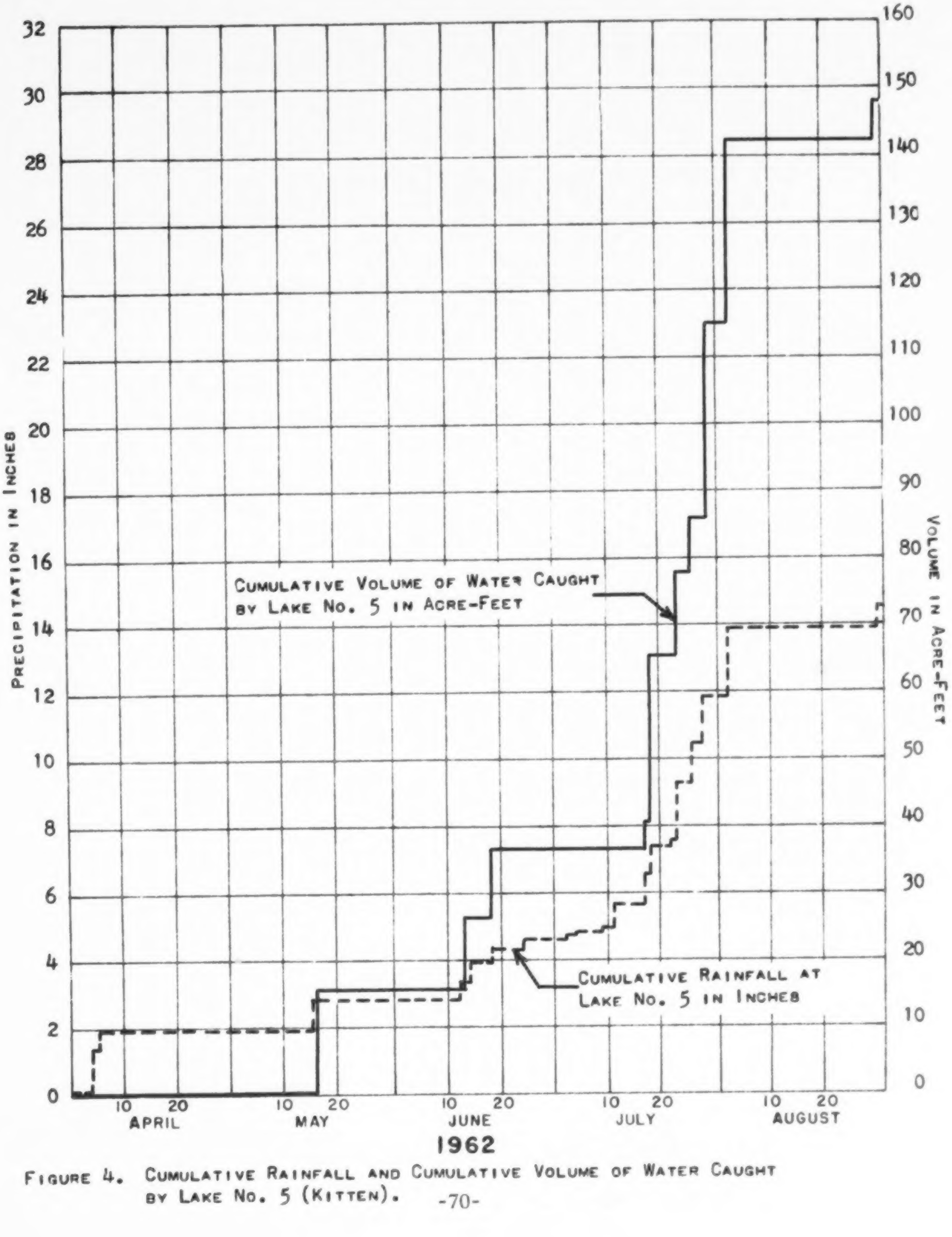

FIGURE 4. CUMULATIVE RAINFALL AND CUMULATIVE VOLUME OF WATER CAUGHT BY LAKE NO. 5 (KITTEN).

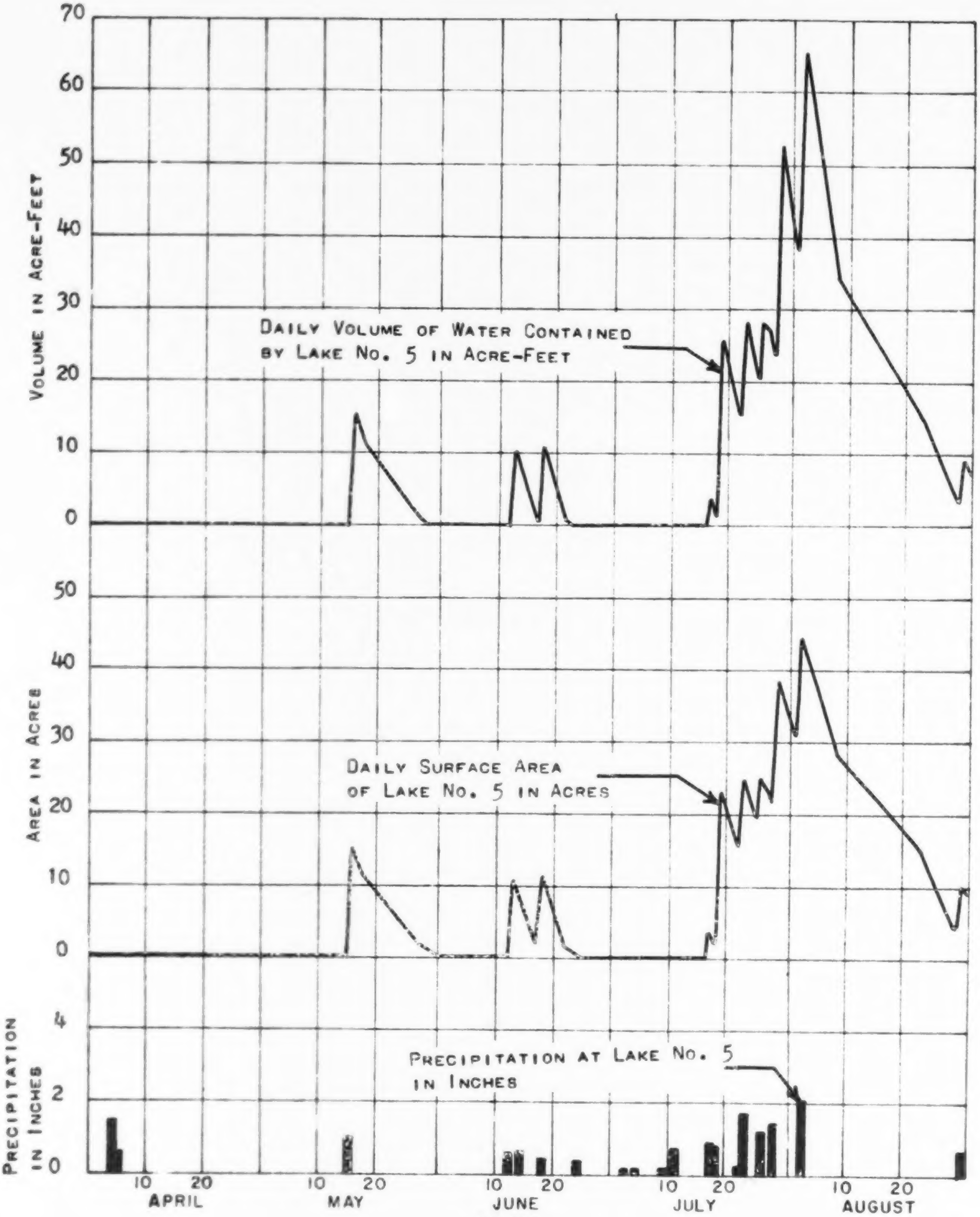

Figure 5. Daily Volume of Water Contained by Lake, Daily Surface Area of Lake and Precipitation at Lake No. 5 (Kitten).

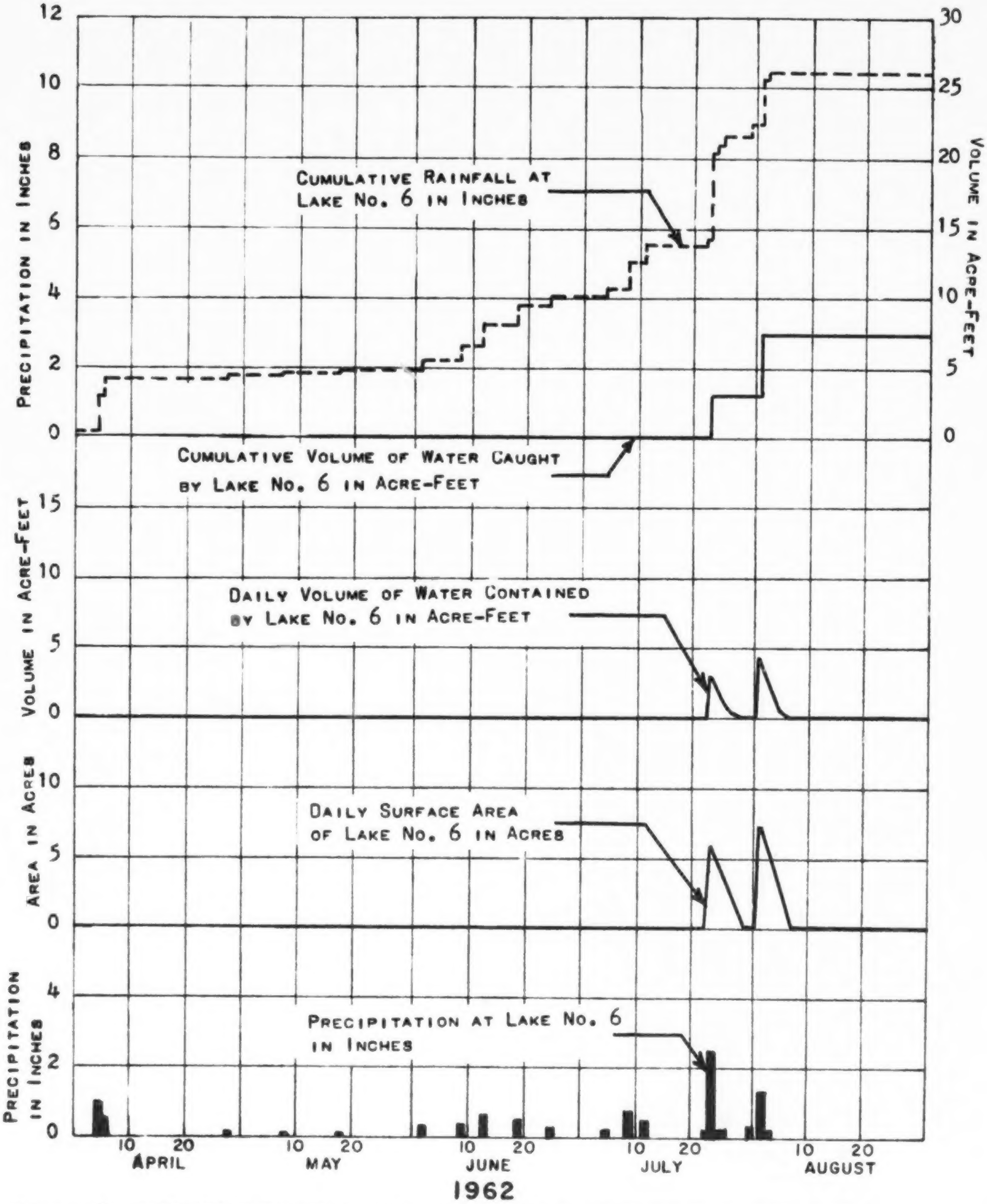

Figure 6. CUMULATIVE RAINFALL, CUMULATIVE VOLUME OF WATER CAUGHT BY LAKE, DAILY VOLUME OF WATER CONTAINED BY LAKE, DAILY SURFACE AREA OF LAKE, AND PRECIPITATION AT LAKE NO. 6 (HOLLAND).

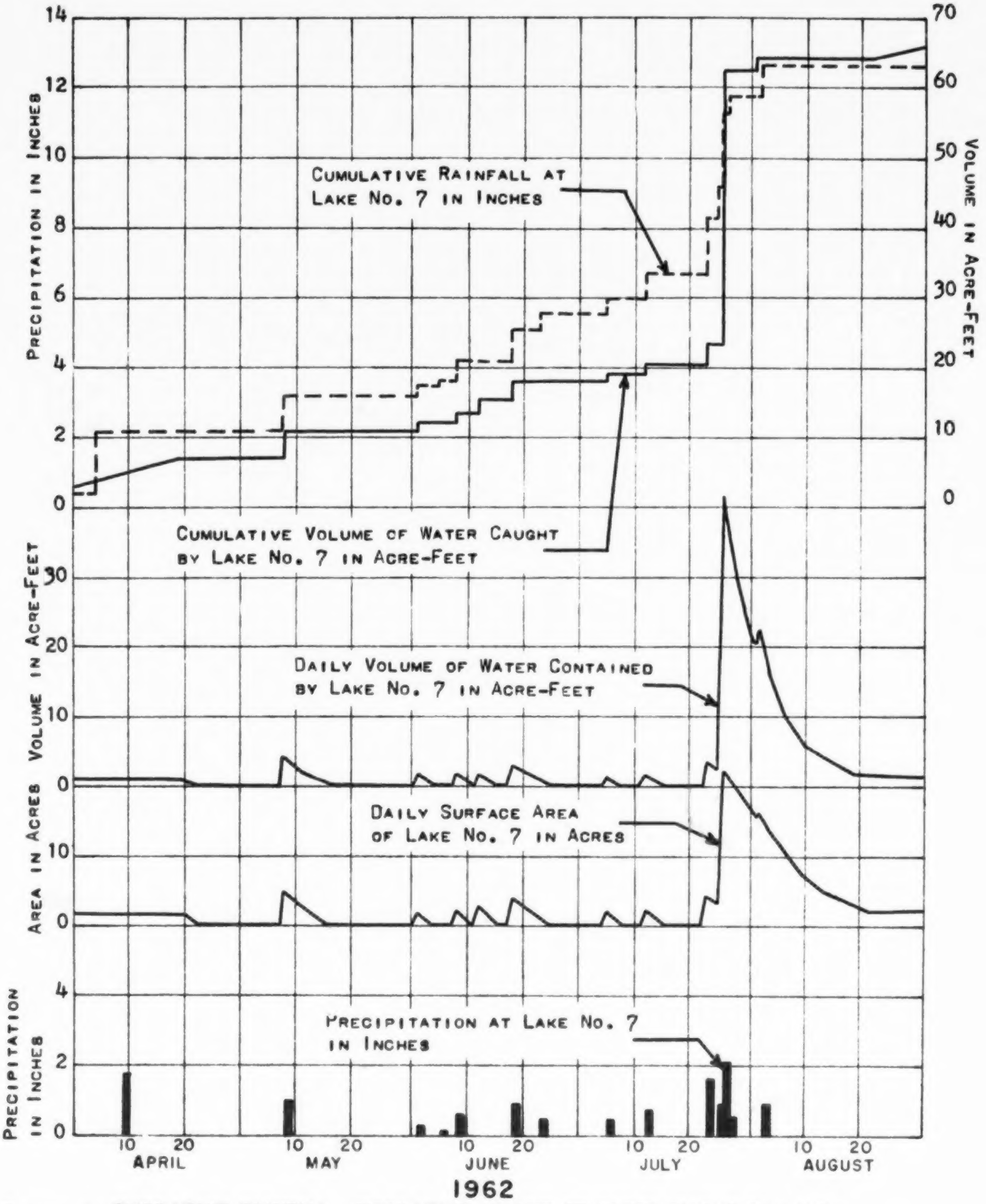

Figure 7. CUMULATIVE RAINFALL, CUMULATIVE VOLUME OF WATER CAUGHT BY LAKE, DAILY VOLUME OF WATER CONTAINED BY LAKE, DAILY SURFACE AREA OF LAKE, AND PRECIPITATION AT LAKE NO. 7 (COOPER).

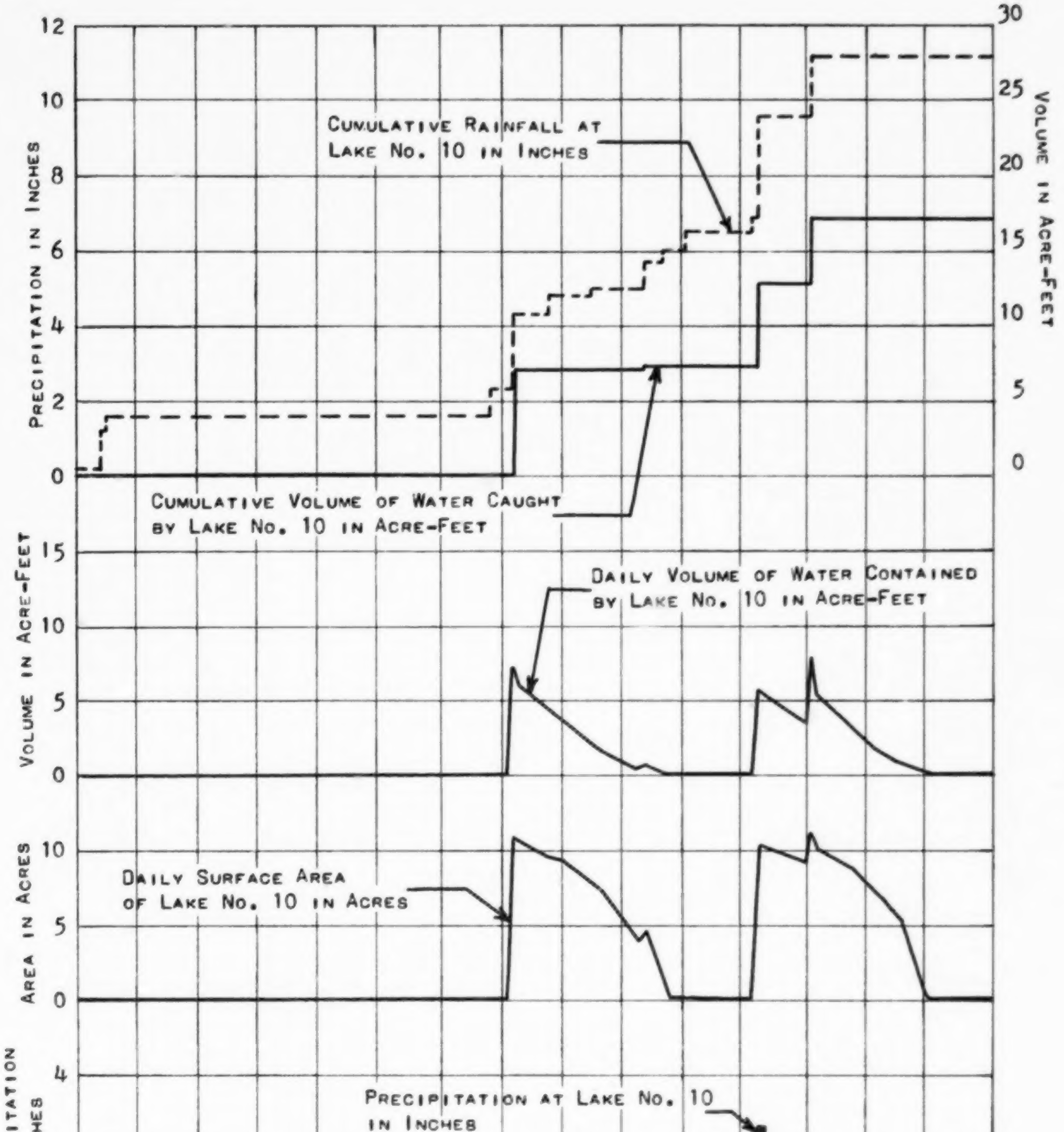

FIGURE 8. CUMULATIVE RAINFALL, CUMULATIVE VOLUME OF WATER CAUGHT BY LAKE, DAILY VOLUME OF WATER CONTAINED BY LAKE, DAILY SURFACE AREA OF LAKE, AND PRECIPITATION AT LAKE NO. 10 (DUPREE).

APPENDIX III. Mosquito Larvae Dipping Form

APPENDIX III Field Data Sheet used for mosquito larvae dipping

Lake ______________________

					No. of	No. in each instar					
Stop	Cover	weed	grass	depth	Larvae	1st	2nd	3rd	4th	Pupae	Remarks

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APPENDIX IV. Mosquito Larvae Production Graphs

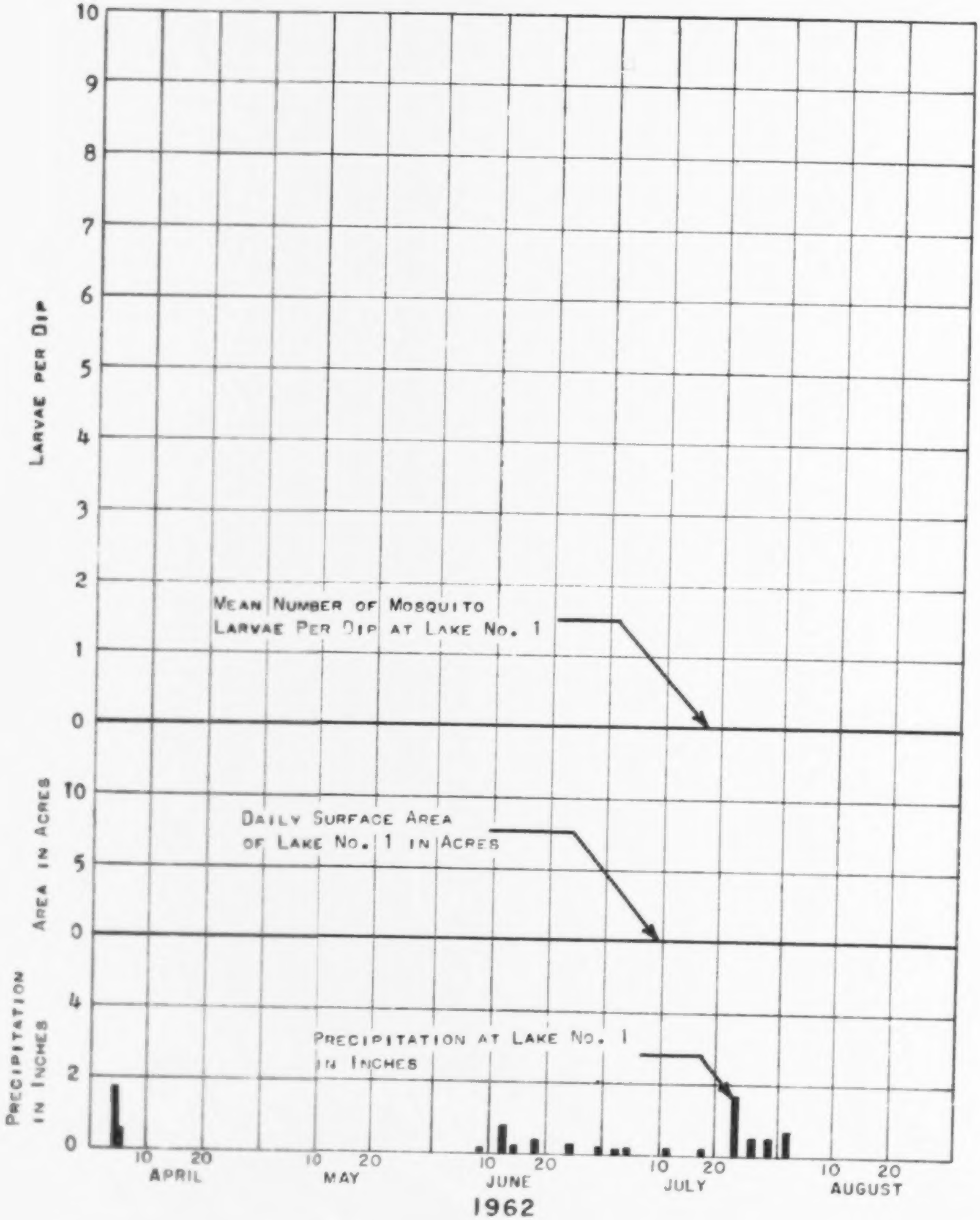

Figure 1. Mean numbers of mosquito larvae per dip taken twice weekly by sampling at thirty foot intervals on ten transects; in relation to Daily Surface Area and Rainfall. Summer 1962. Lake 1.

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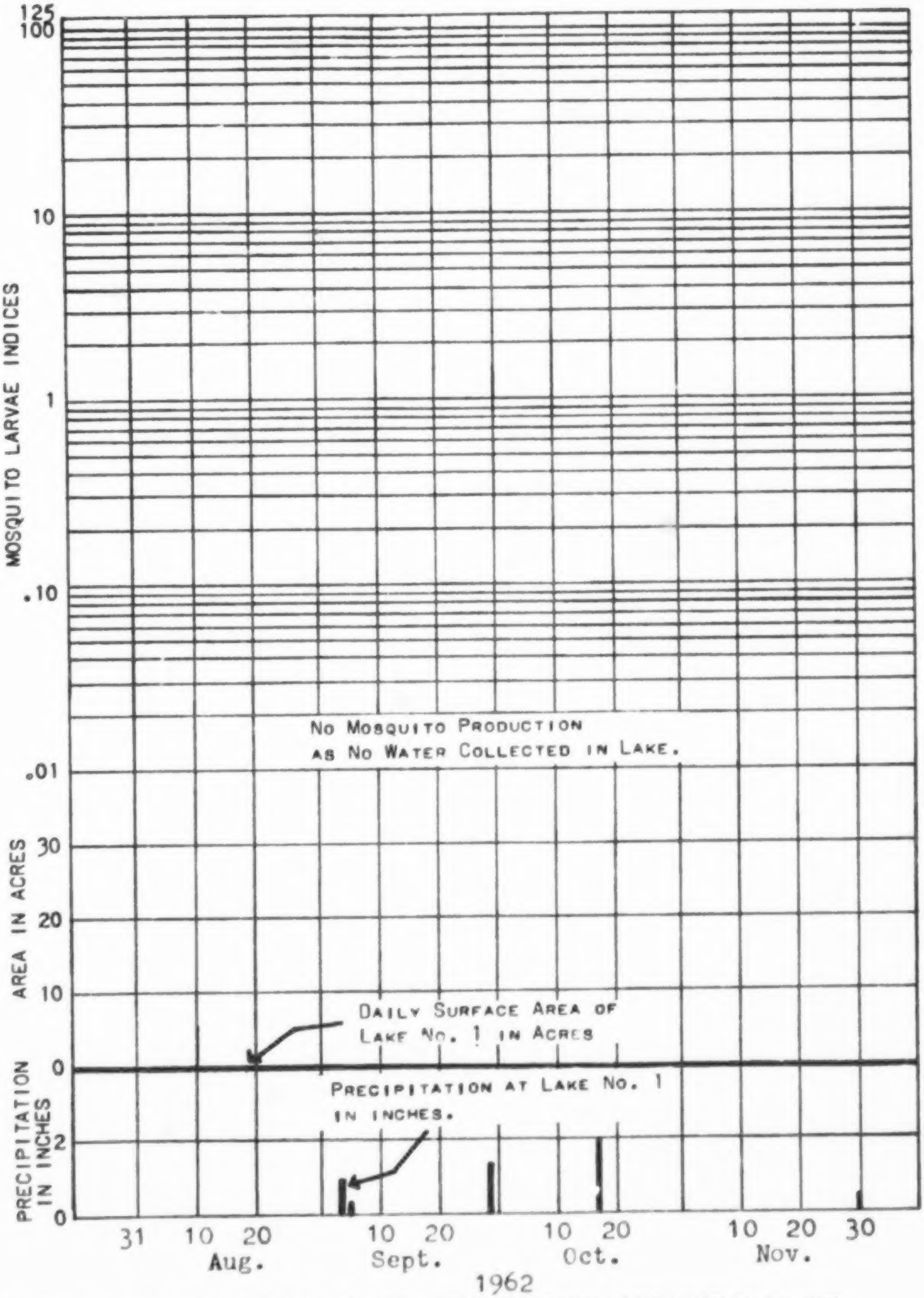

FIGURE 1B MOSQUITO LARVAE INDICES PRESENTED SEMI-LOGARITHMICALLY FOR BOTH FOURTH INSTAR LARVAE AND TOTAL OF ALL INSTARS TAKEN TWICE WEEKLY BY SAMPLING AT THIRTY FOOT INTERVALS ON TEN TRANSECTS; IN RELATION TO DAILY SURFACE ACRES AND RAINFALL. SUMMER AND FALL 1962. LAKE 1 (HUCKABEE).

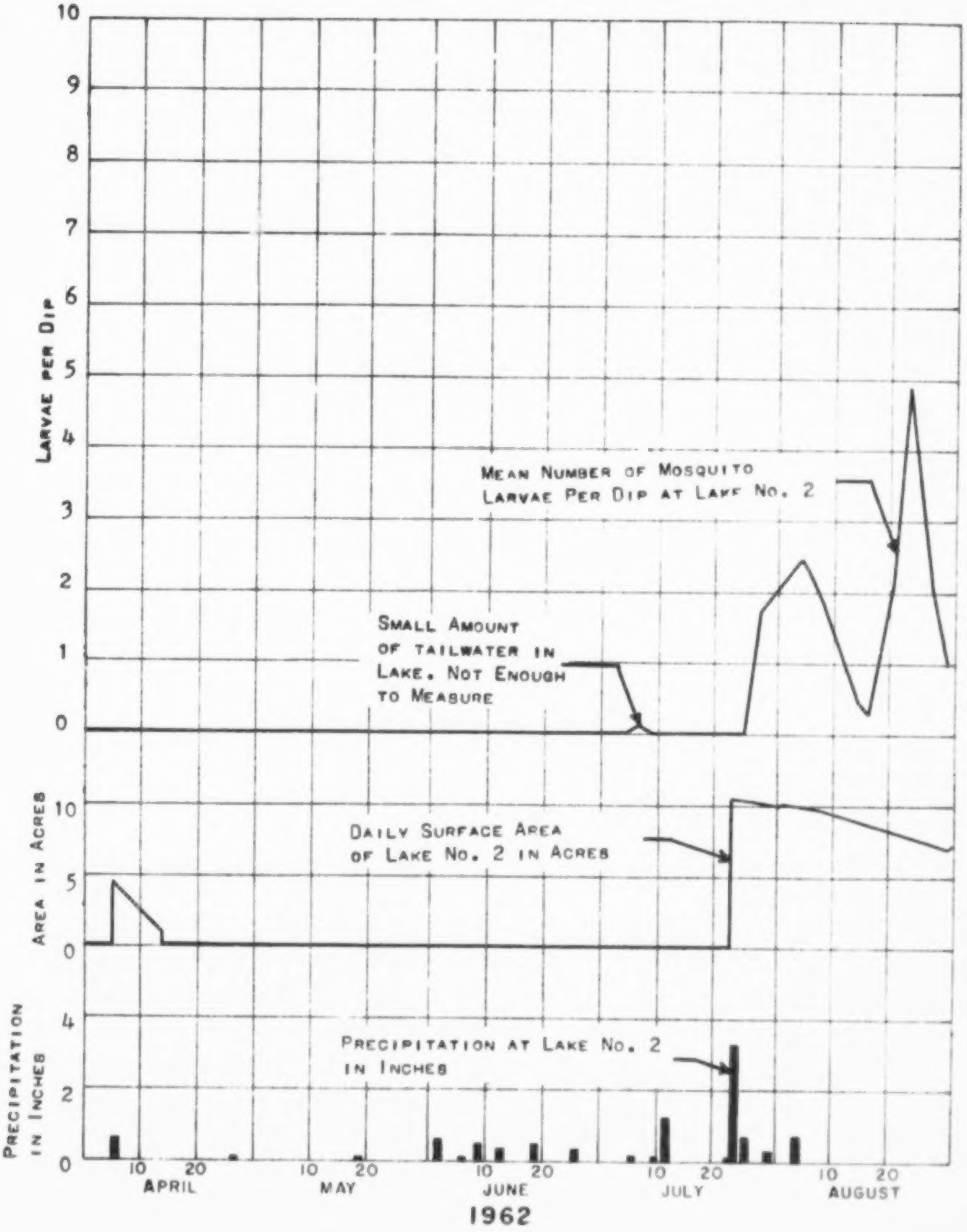

Figure 2. Mean numbers of mosquito larvae per dip taken twice weekly by sampling at thirty foot intervals on ten transects; in relation to Daily Surface Area and Rainfall. Summer 1962. Lake 2.

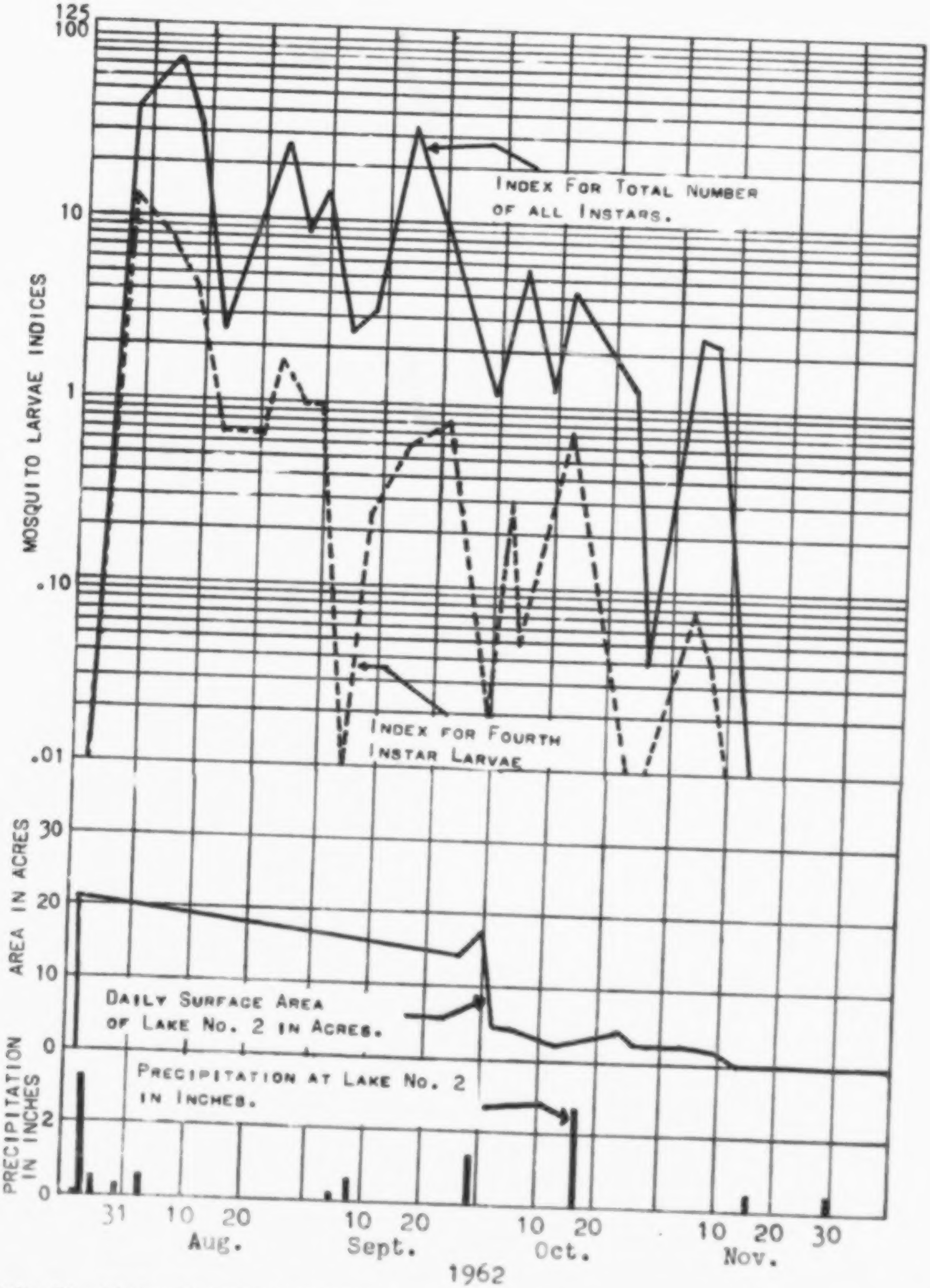

FIGURE 28 MOSQUITO LARVAE INDICES PRESENTED SEMI-LOGARITHMICALLY FOR BOTH FOURTH INSTAR LARVAE AND TOTAL OF ALL INSTARS TAKEN TWICE WEEKLY BY SAMPLING AT THIRTY FOOT INTERVALS ON TEN TRANSECTS; IN RELATION TO DAILY SURFACE ACRES AND RAINFALL. SUMMER AND FALL 1962. LAKE 2 (KNOWLES).

Reproduced from best available copy.

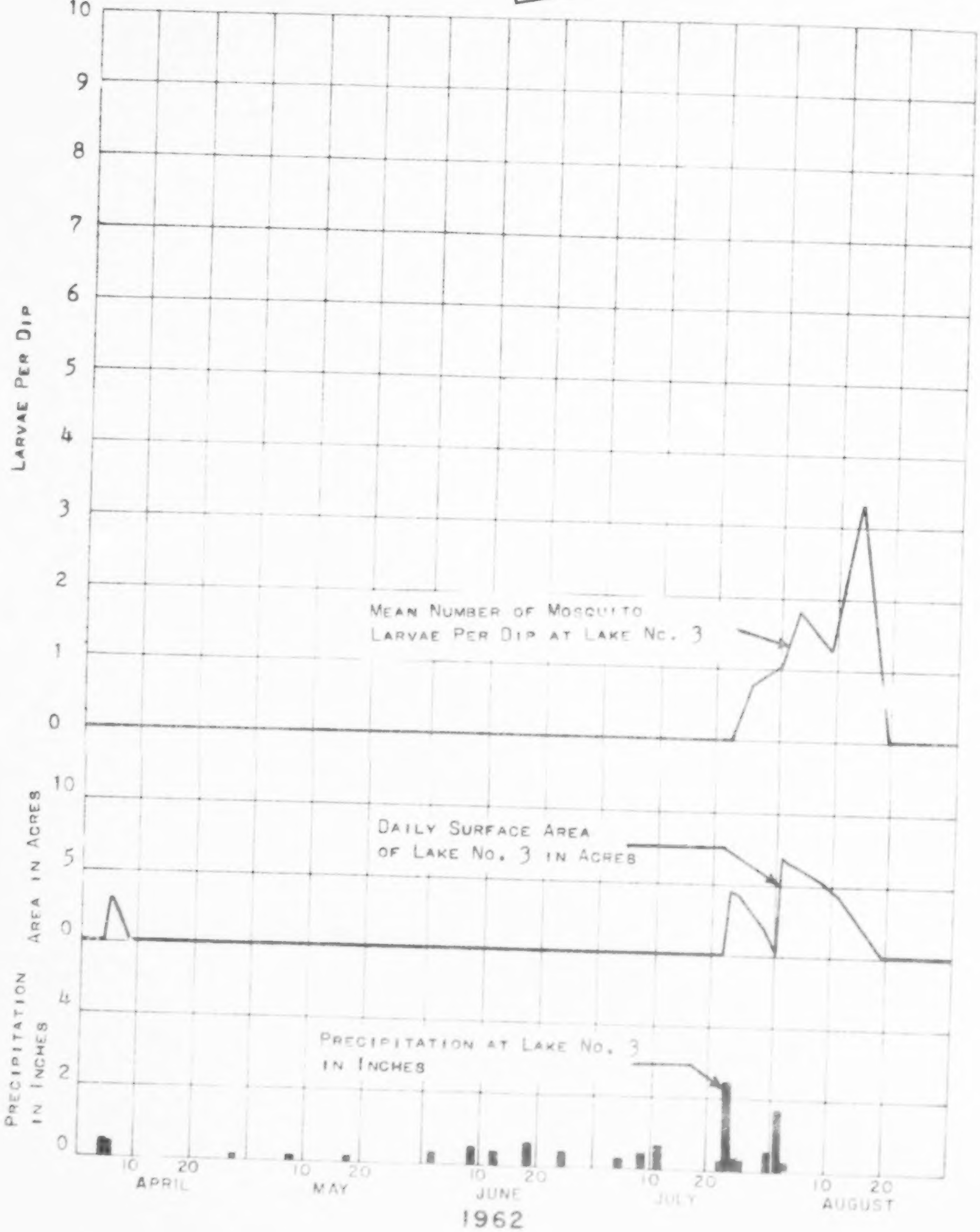

Figure 3. Mean numbers of mosquito larvae per dip taken twice weekly by sampling at thirty foot intervals on ten transects; in relation to Daily Surface Area and Rainfall, Summer 1962. Lake 3.

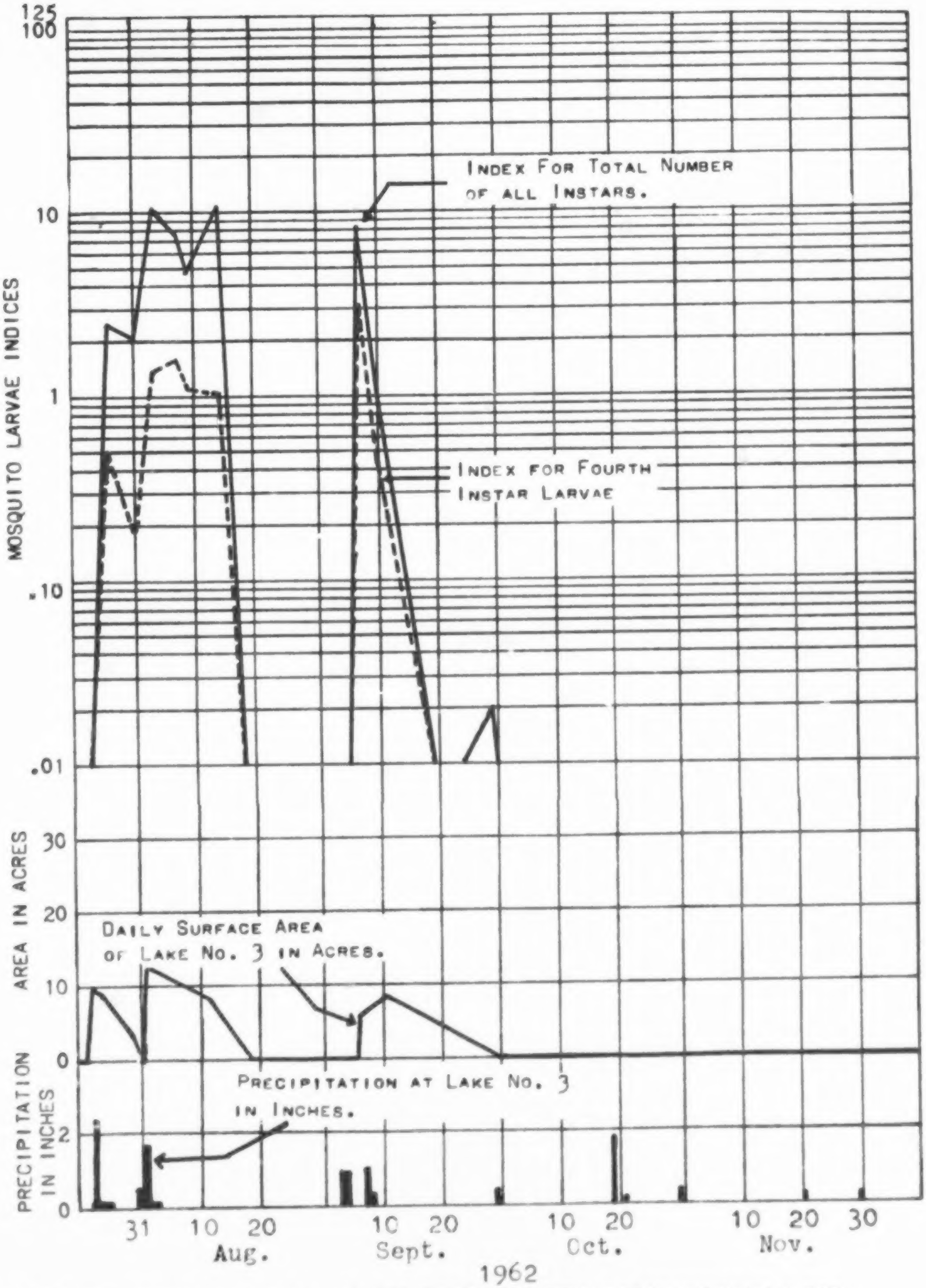

FIGURE 3B MOSQUITO LARVAE INDICES PRESENTED SEMI-LOGARITHMICALLY FOR BOTH FOURTH INSTAR LARVAE AND TOTAL OF ALL INSTARS TAKEN TWICE WEEKLY BY SAMPLING AT THIRTY FOOT INTERVALS ON TEN TRANSECTS; IN RELATION TO DAILY SURFACE ACRES AND RAINFALL. SUMMER AND FALL 1962. LAKE 3 (HUFFSTEDLER).

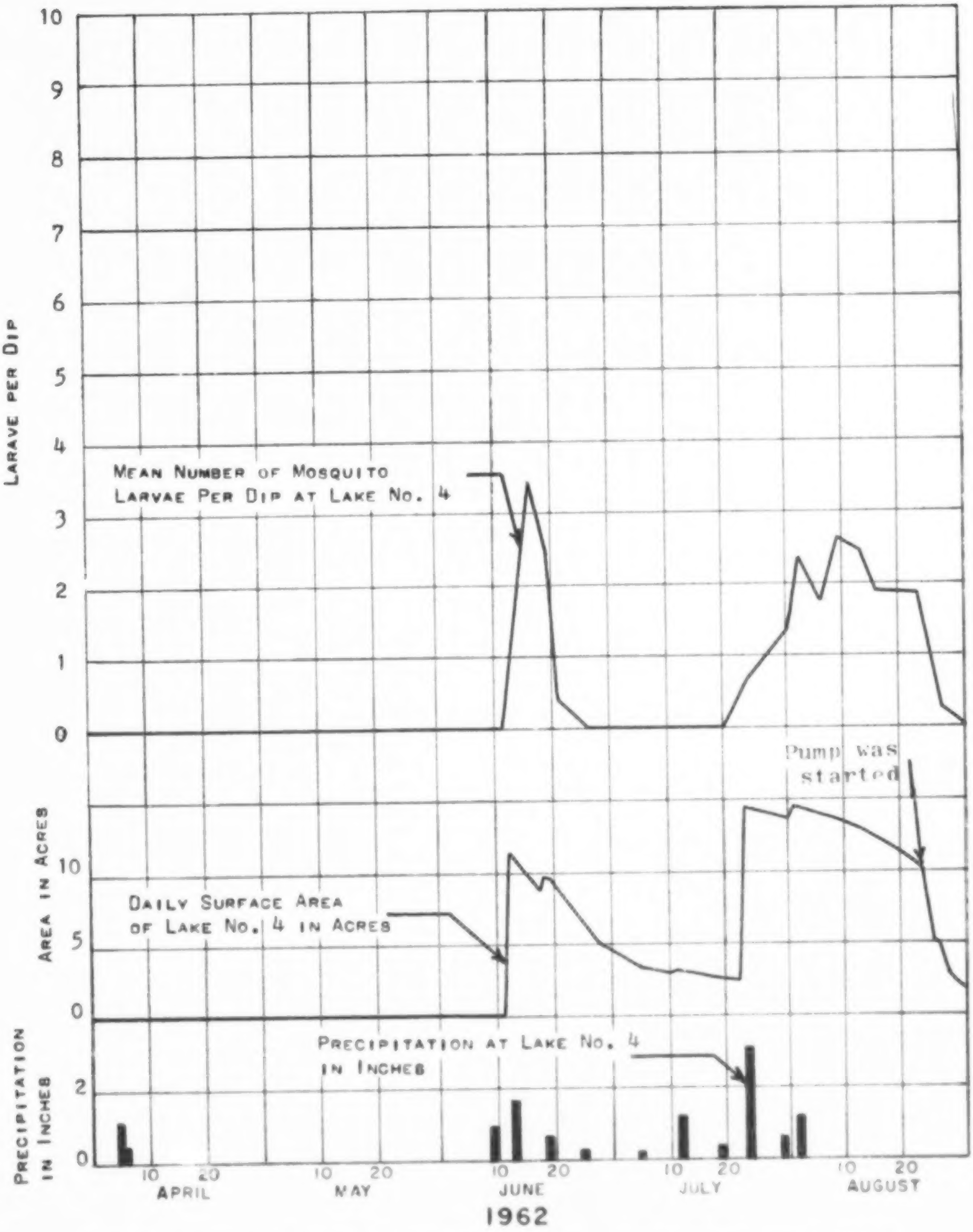

Figure 4. Mean numbers of mosquito larvae per dip taken twice weekly by sampling at thirty foot intervals on ten transects; in relation to Daily Surface Area and Rainfall. Summer 1962. Lake 4.

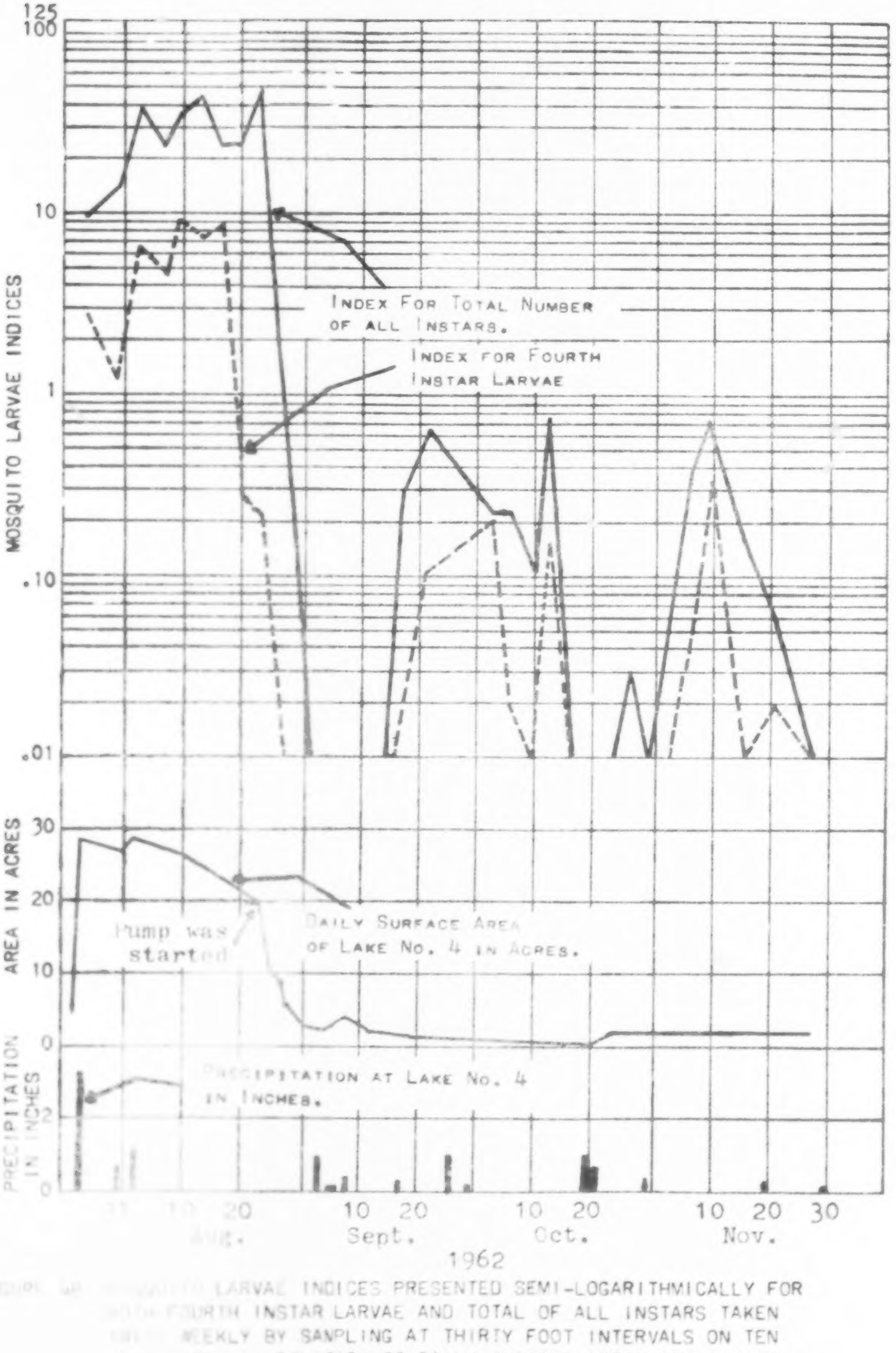

FIGURE 48. MOSQUITO LARVAE INDICES PRESENTED SEMI-LOGARITHMICALLY FOR BOTH FOURTH INSTAR LARVAE AND TOTAL OF ALL INSTARS TAKEN ONCE WEEKLY BY SAMPLING AT THIRTY FOOT INTERVALS ON TEN TRANSECTS; IN RELATION TO DAILY SURFACE ACRES AND RAINFALL. SUMMER AND FALL 1962. LAKE 4 (L.C.C.).

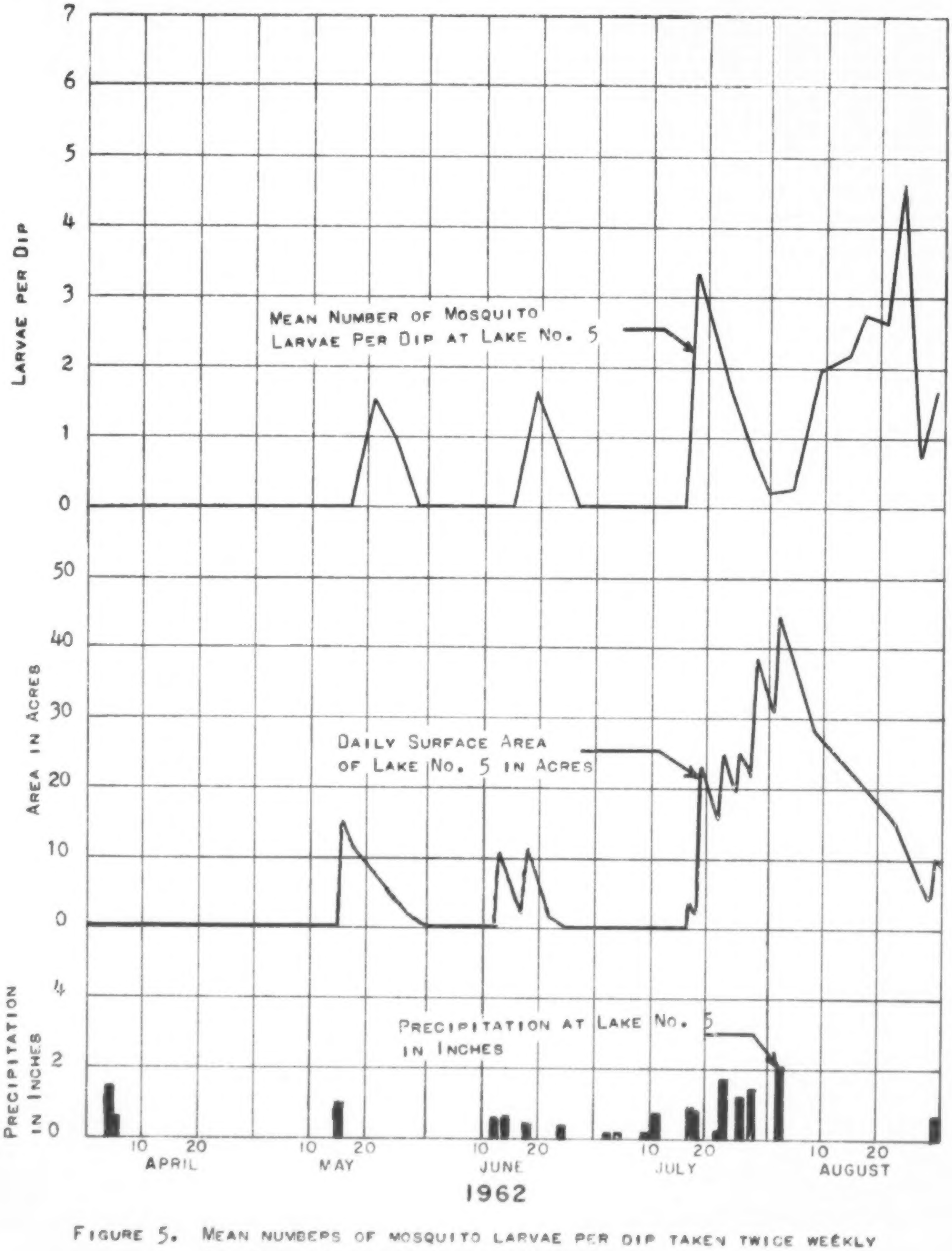

Figure 5. Mean numbers of mosquito larvae per dip taken twice weekly by sampling at thirty foot intervals on ten transects; in relation to Daily Surface Area and Rainfall. Summer 1962. Lake 5.

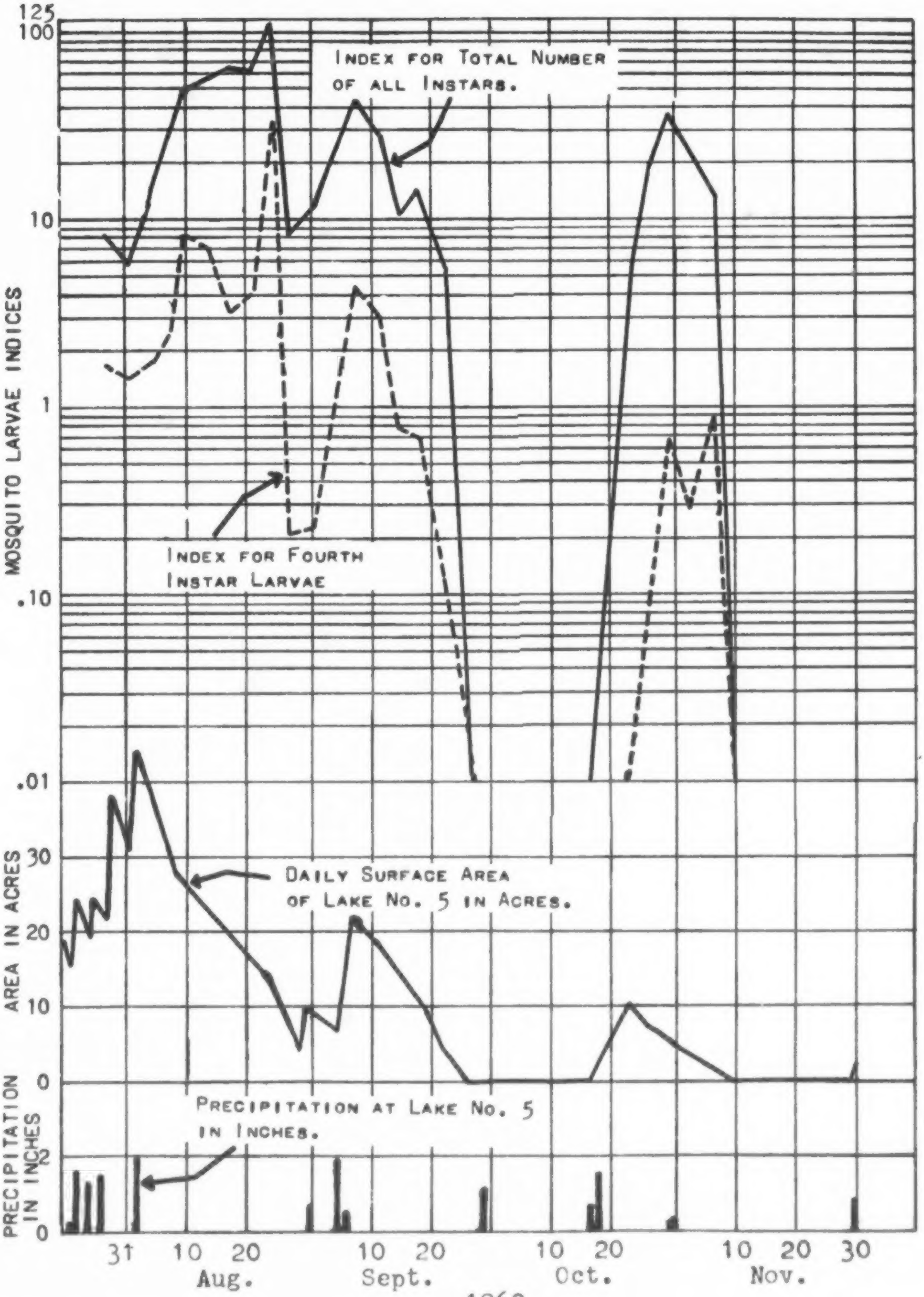

FIGURE 5B MOSQUITO LARVAE INDICES PRESENTED SEMI-LOGARITHMICALLY FOR BOTH FOURTH INSTAR LARVAE AND TOTAL OF ALL INSTARS TAKEN TWICE WEEKLY BY SAMPLING AT THIRTY FOOT INTERVALS ON TEN TRANSECTS; IN RELATION TO DAILY SURFACE ACRES AND RAINFALL. SUMMER AND FALL 1962. LAKE 5 (KITTEN'S).

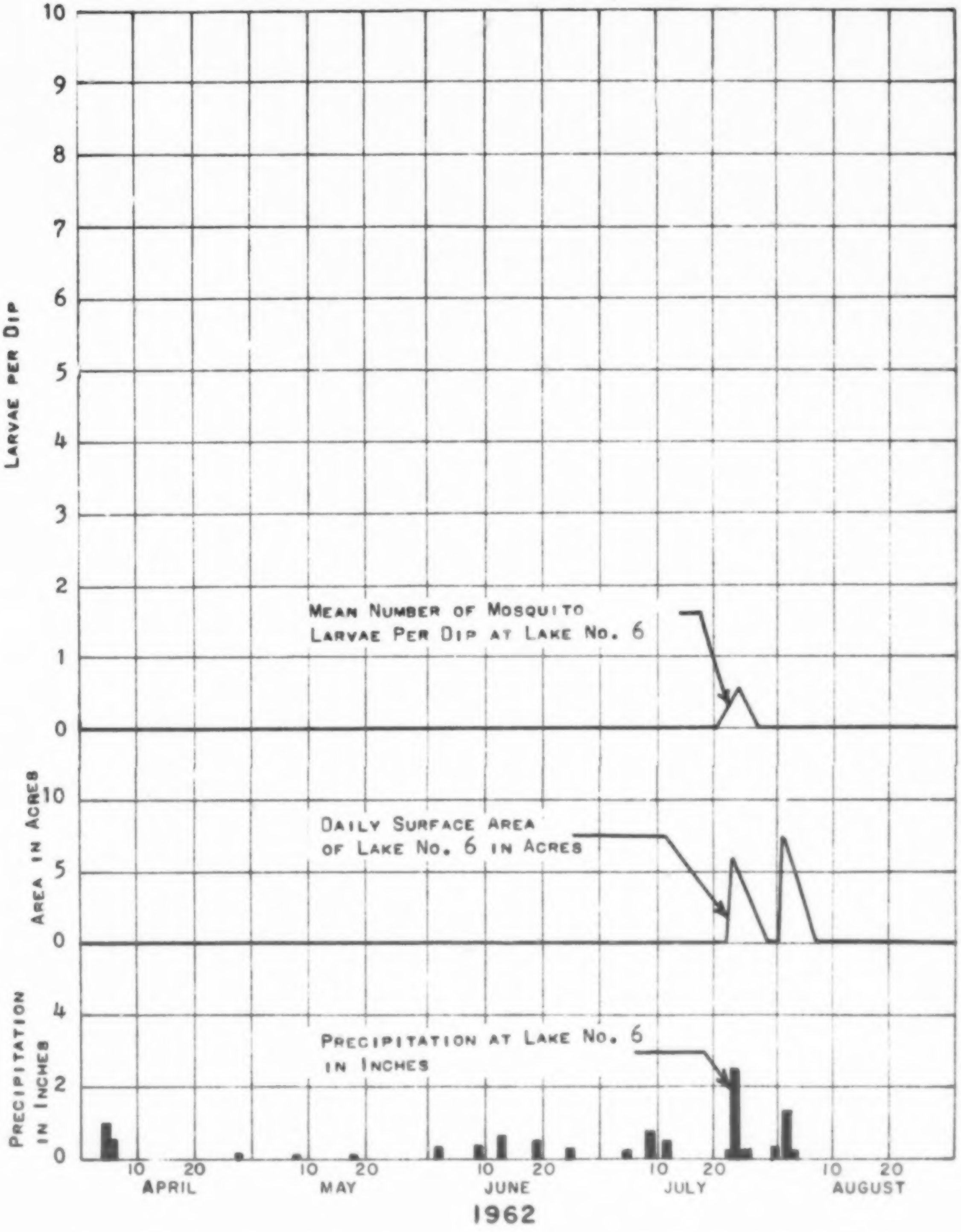

Figure 6. Mean numbers of mosquito larvae per dip taken twice weekly by sampling at thirty foot intervals on ten transects; in relation to Daily Surface Area and Rainfall. Summer 1962. Lake 6.

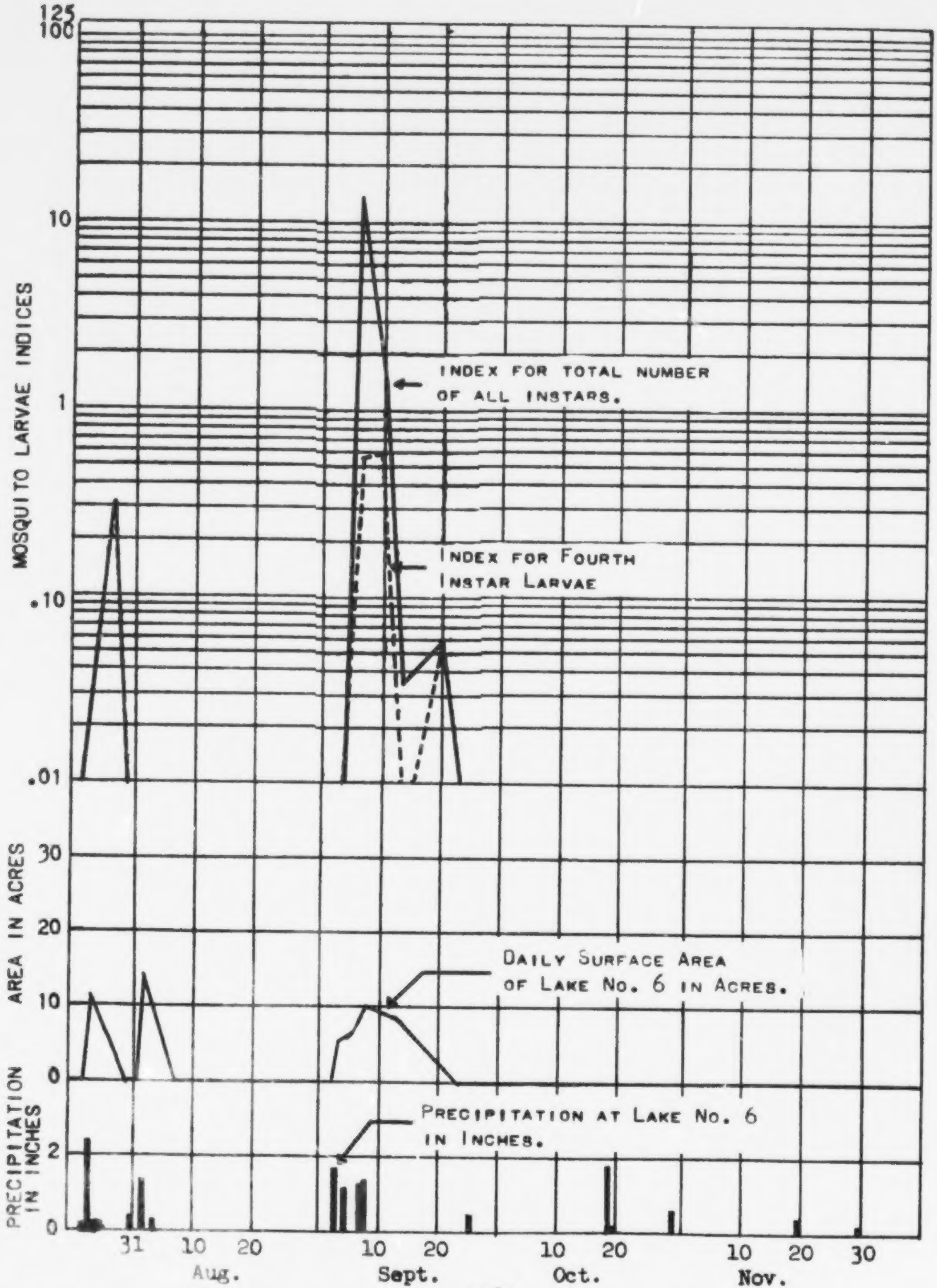

FIGURE 68 MOSQUITO LARVAE ,INDICES PRESENTED SEMI-LOGARITHMICALLY FOR BOTH FOURTH INSTAR LARVAE AND TOTAL OF ALL INSTARS TAKEN TWICE WEEKLY BY SAMPLING AT THIRTY FOOT INTERVALS ON TEN TRANSECTS; IN RELATION TO DAILY SURFACE ACRES AND RAINFALL. SUMMER AND FALL 1962. LAKE 6 (HOLLAND).

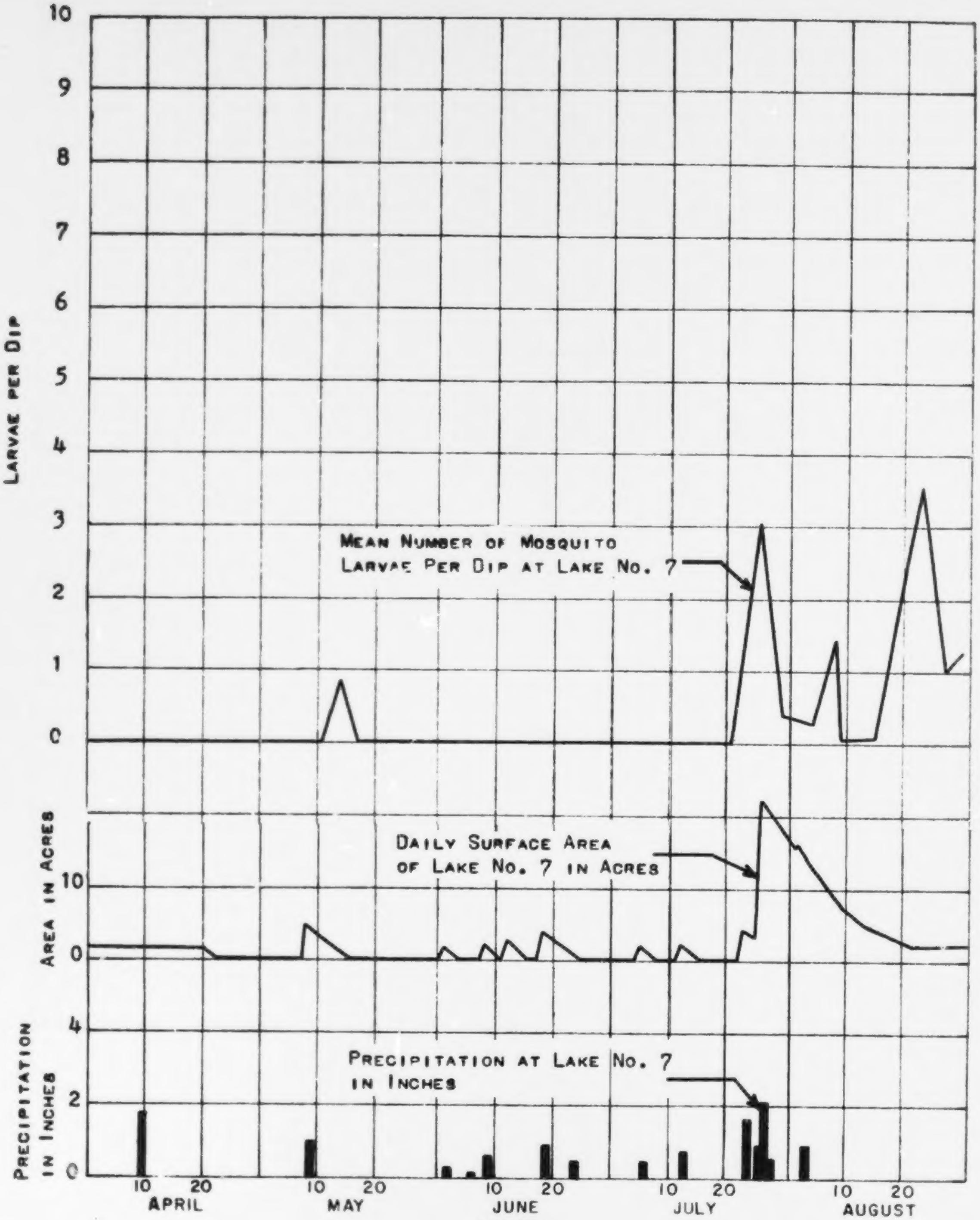

FIGURE 7. MEAN NUMBERS OF MOSQUITO LARVAE PER DIP TAKEN TWICE WEEKLY BY SAMPLING AT THIRTY FOOT INTERVALS ON TEN TRANSECTS; IN RELATION TO DAILY SURFACE AREA AND RAINFALL. SUMMER 1962. LAKE 7.

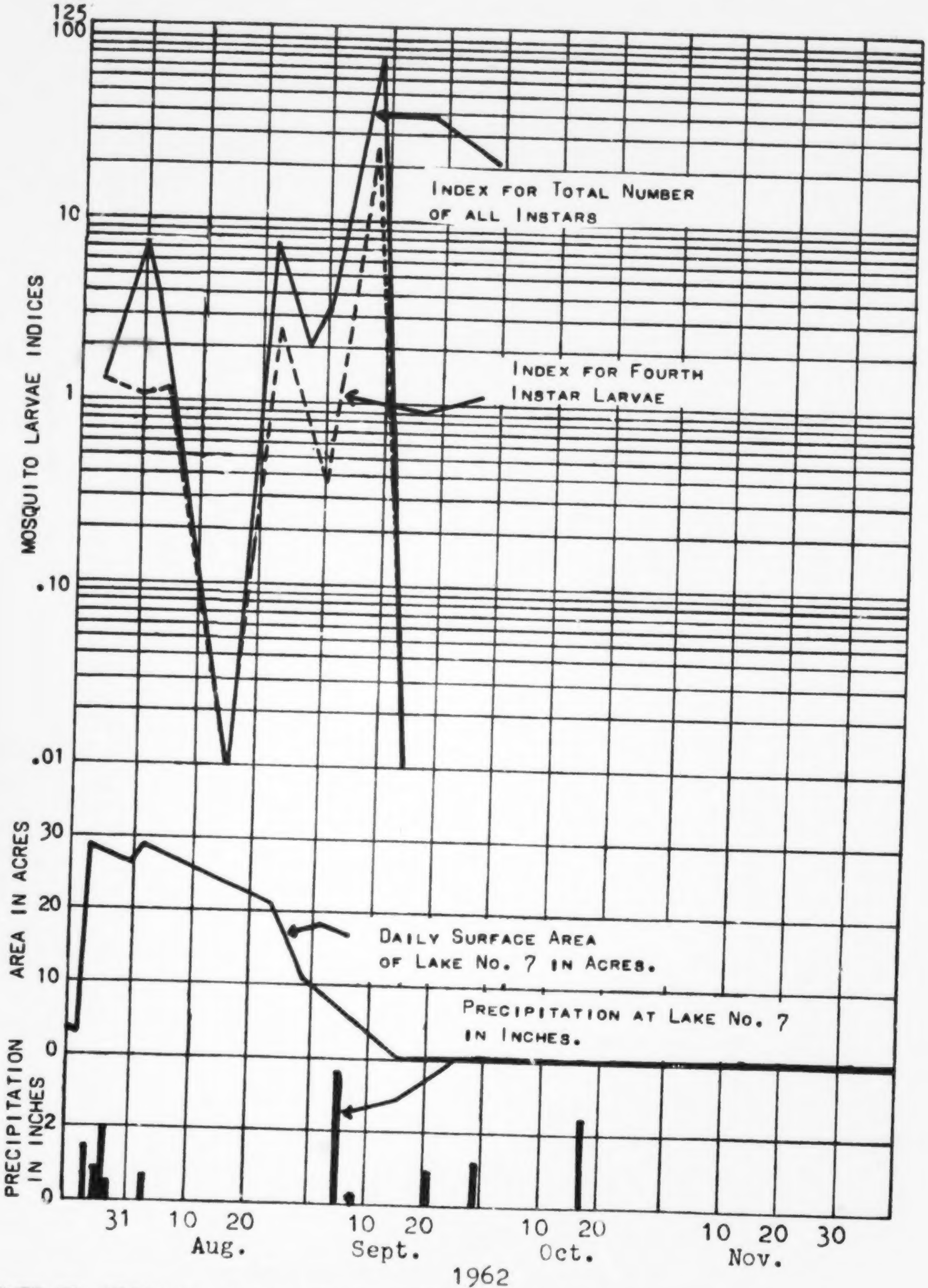

FIGURE 7B MOSQUITO LARVAE INDICES PRESENTED SEMI-LOGARITHMICALLY FOR BOTH FOURTH INSTAR LARVAE AND TOTAL OF ALL INSTARS TAKEN TWICE WEEKLY BY SAMPLING AT THIRTY FOOT INTERVALS ON TEN TRANSECTS; IN RELATION TO DAILY SURFACE ACRES AND RAINFALL. SUMMER AND FALL 1962. LAKE 7 (COOPER).

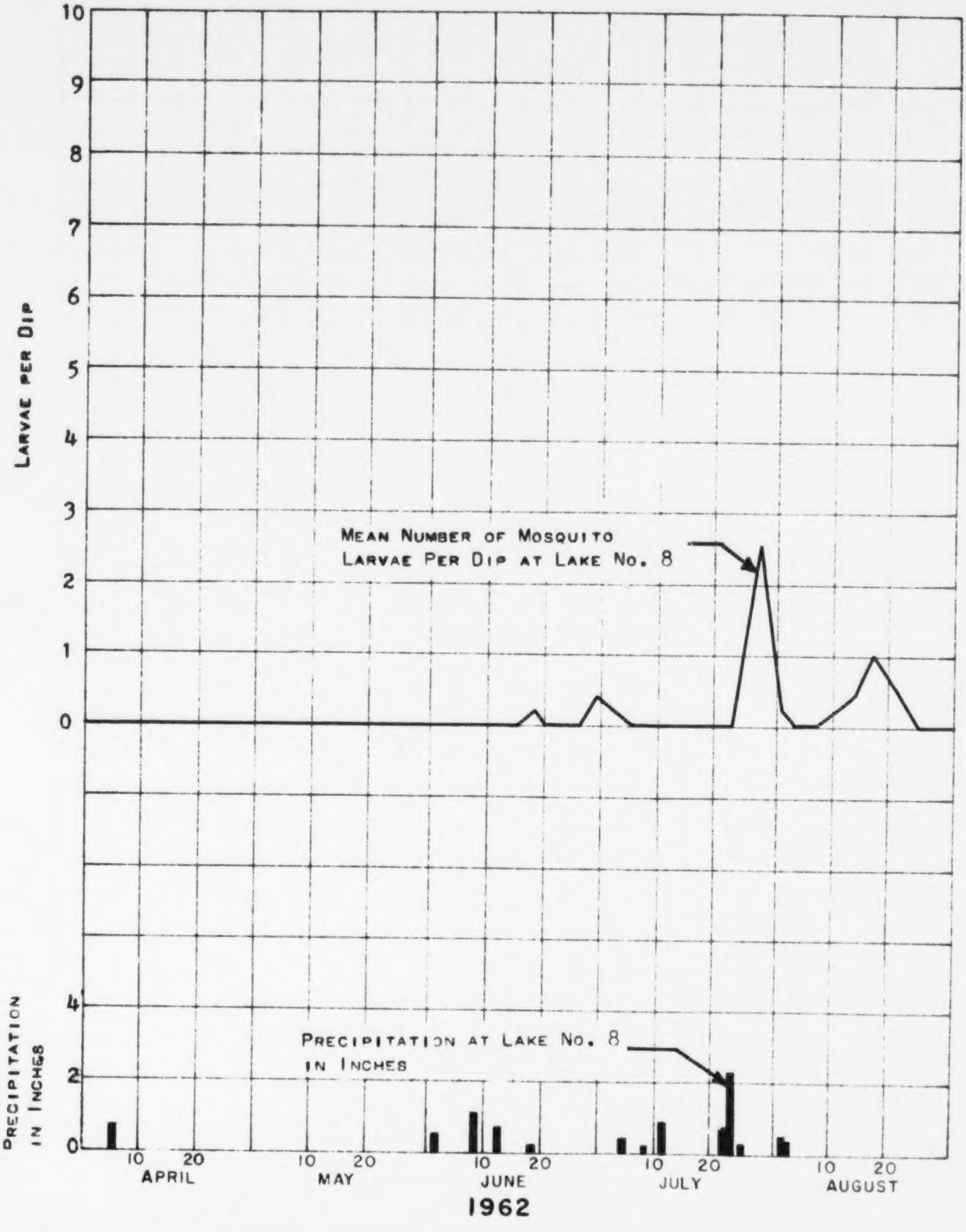

Figure 8. Mean number of mosquito larve per dip taken twice weekly by sampling at thirty foot intervals on ten transects; in relation to Rainfall. Summer 1962. Lake 8.

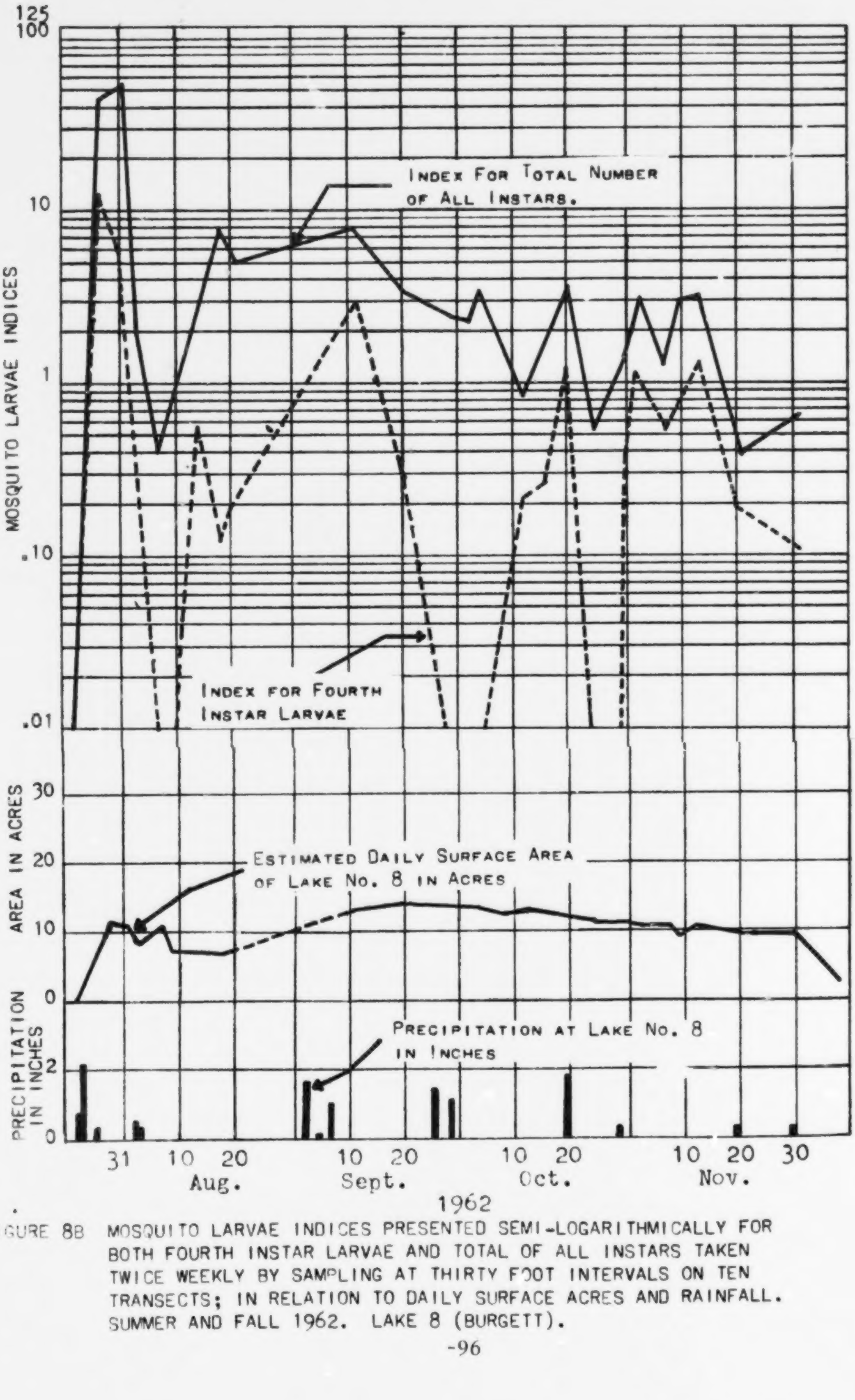

FIGURE 8B MOSQUITO LARVAE INDICES PRESENTED SEMI-LOGARITHMICALLY FOR BOTH FOURTH INSTAR LARVAE AND TOTAL OF ALL INSTARS TAKEN TWICE WEEKLY BY SAMPLING AT THIRTY FOOT INTERVALS ON TEN TRANSECTS; IN RELATION TO DAILY SURFACE ACRES AND RAINFALL. SUMMER AND FALL 1962. LAKE 8 (BURGETT).

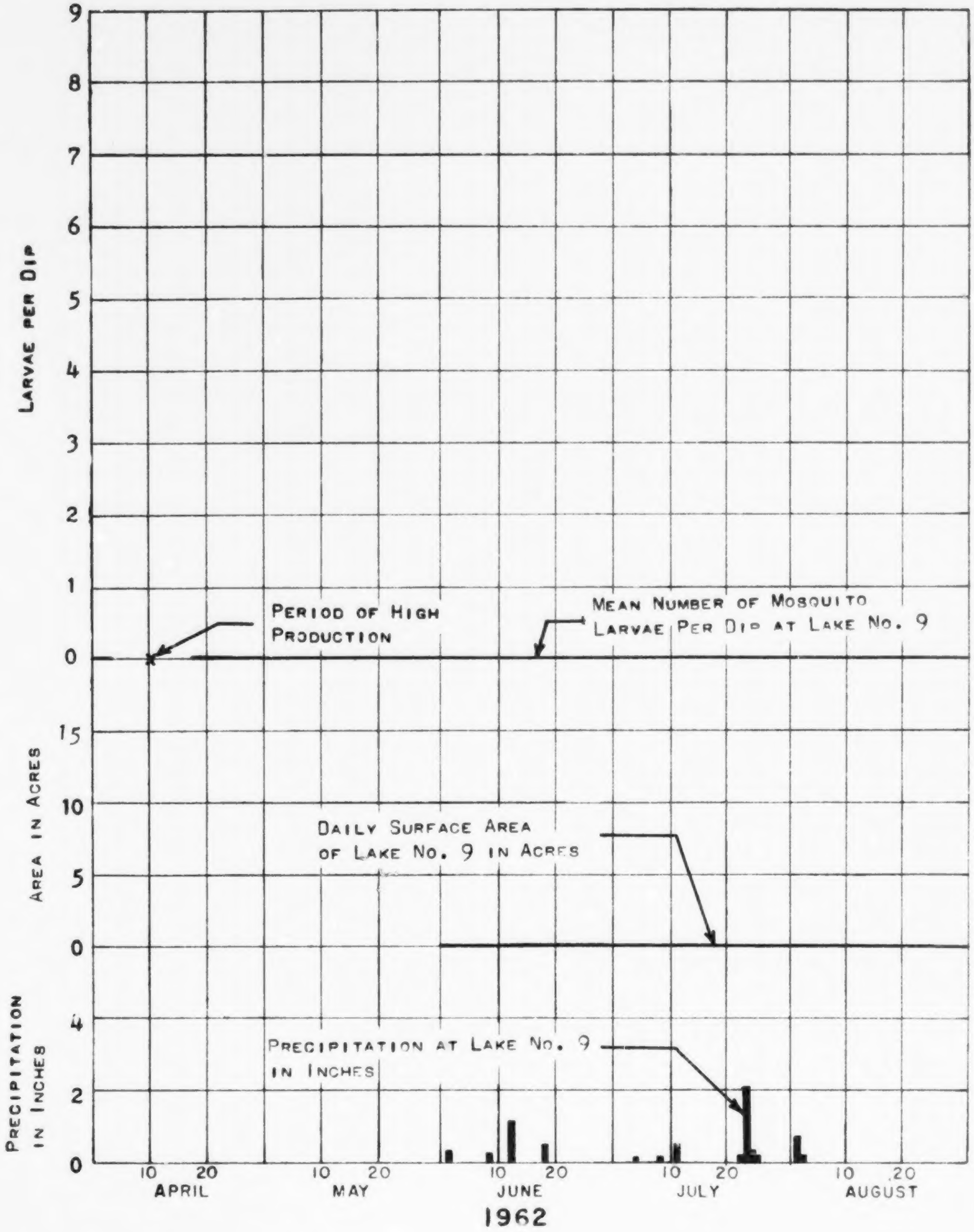

Figure 9. Mean numbers of mosquito larvae per dip taken twice weekly by sampling at thirty foot intervals on ten transects; in relation to Daily Surface Area and Rainfall. Summer 1962. Lake 9. No rainfall or runoff data was kept on this lake prior to June 1, 1962.

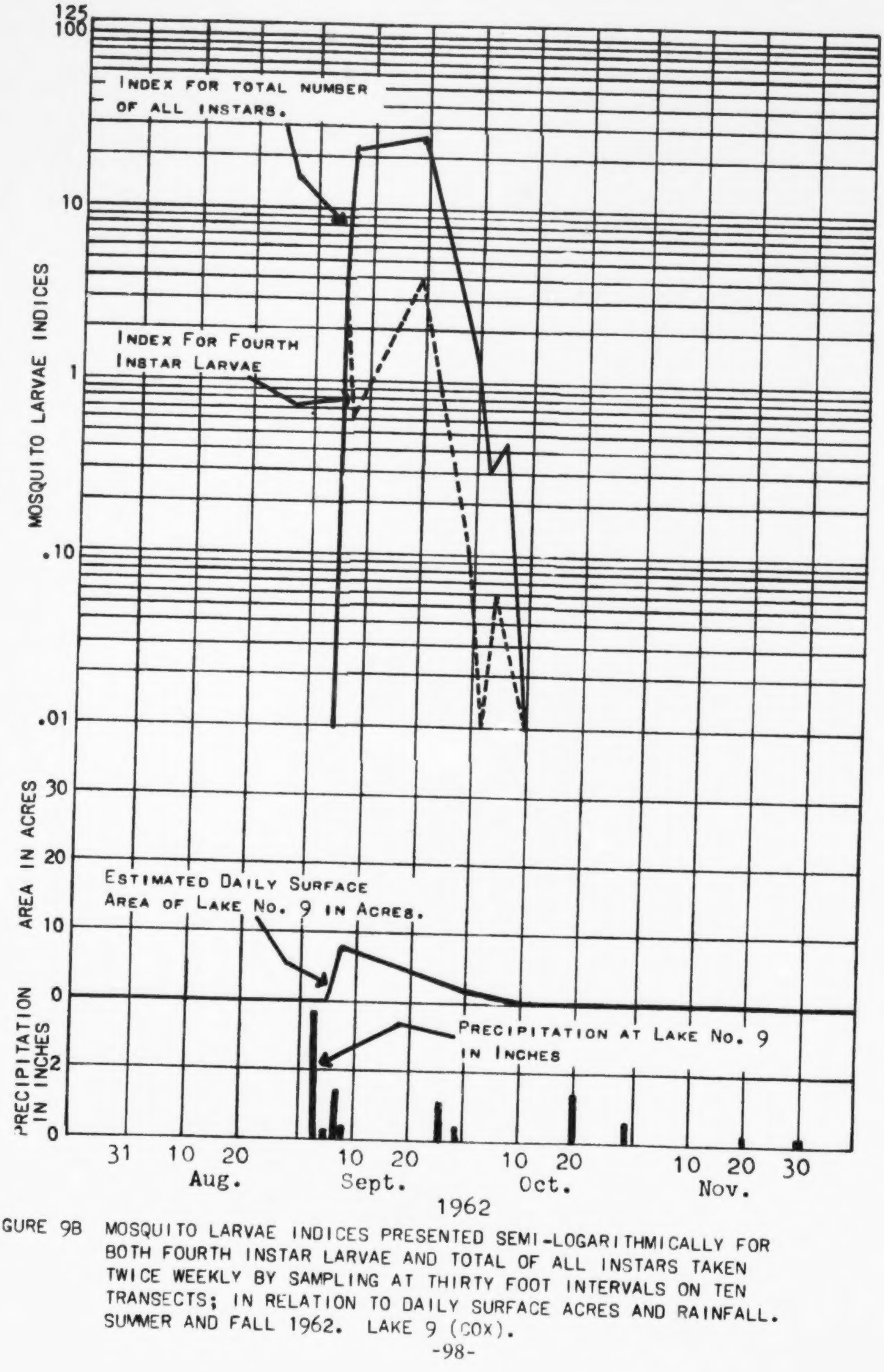

FIGURE 9B MOSQUITO LARVAE INDICES PRESENTED SEMI-LOGARITHMICALLY FOR BOTH FOURTH INSTAR LARVAE AND TOTAL OF ALL INSTARS TAKEN TWICE WEEKLY BY SAMPLING AT THIRTY FOOT INTERVALS ON TEN TRANSECTS; IN RELATION TO DAILY SURFACE ACRES AND RAINFALL. SUMMER AND FALL 1962. LAKE 9 (COX).

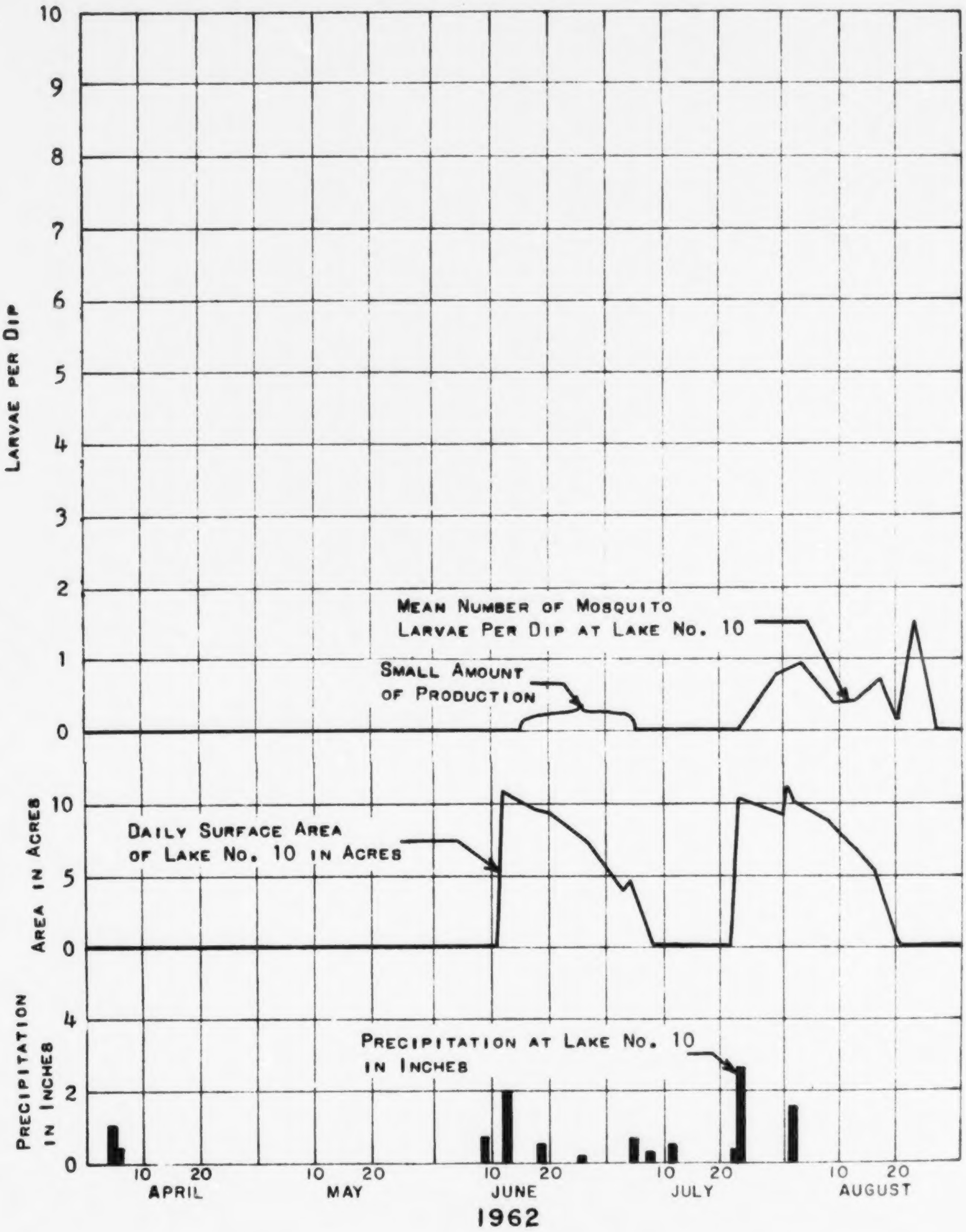

Figure 10. Mean numbers of mosquito larvae per dip taken twice weekly by sampling at thirty foot intervals on ten transects; in relation to Daily Surface Area and Rainfall. Summer 1962. Lake 10.

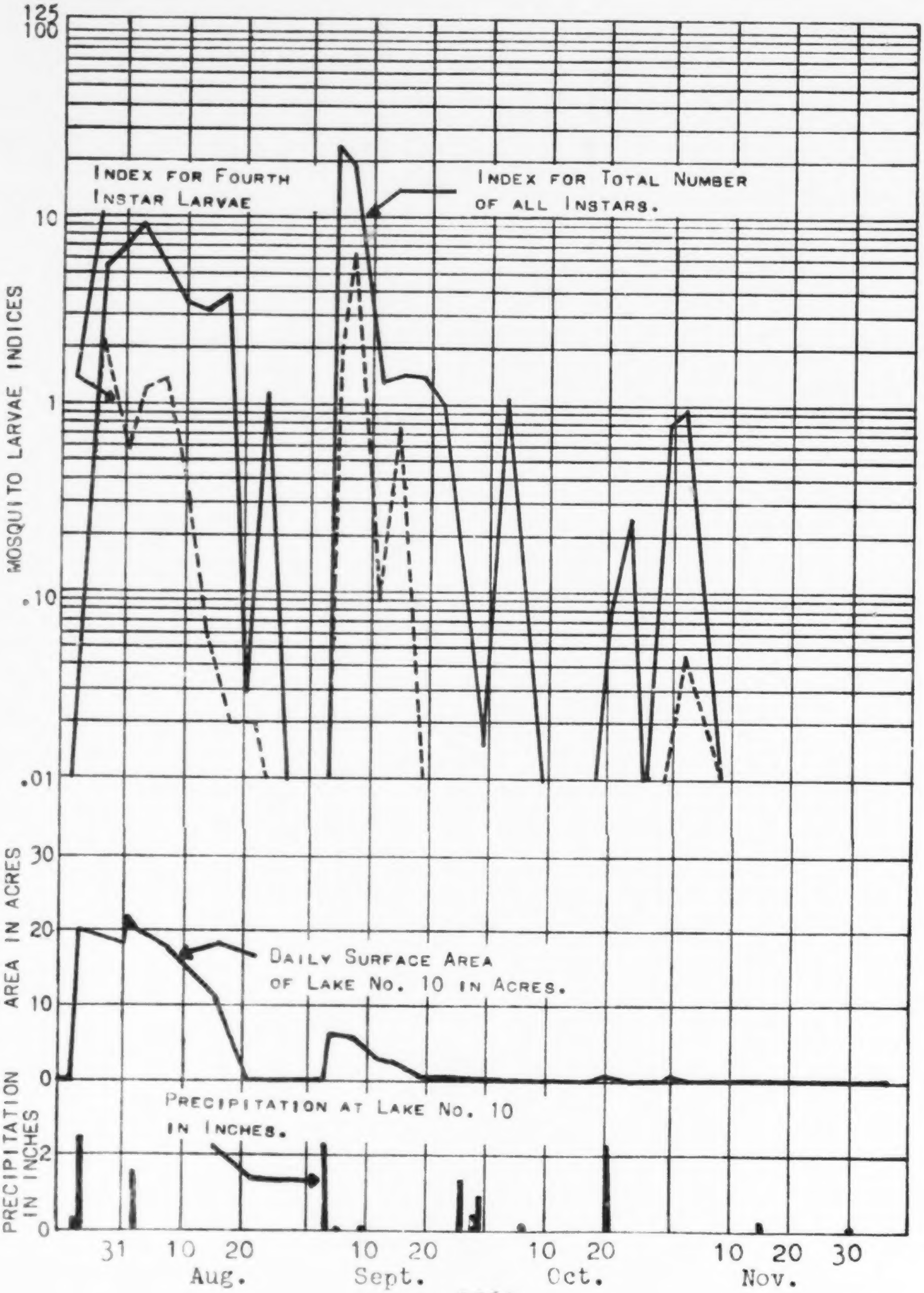

FIGURE 10B MOSQUITO LARVAE INDICES PRESENTED SEMI-LOGARITHMICALLY FOR BOTH FOURTH INSTAR LARVAE AND TOTAL OF ALL INSTARS TAKEN TWICE WEEKLY BY SAMPLING AT THIRTY FOOT INTERVALS ON TEN TRANSECTS; IN RELATION TO DAILY SURFACE ACRES AND RAINFALL. SUMMER AND FALL 1962. LAKE 10 (REESE).

APPENDIX V. Water Chemistry Data

TABLE I Results of complete analysis of water from four representative playas. September and October 1961

CHEMICAL RADICAL	RESULTS IN RPM			
	LAKE I	II[1]	III	IV[2]
Calcium	40	34	54	32
Magnesium	9	4	12	12
Iron	0.98	0.55	6.3	2
Manganese	0.05	0.05	0.05	0.05
Sodium	10	3	27	22
Carbonate	0	0	0	0
Bicarbonate	155	124	196	185
Sulphate	26	8	59	12
Chloride	14	2	26	14
Fluoride	1.1	1.2	1.2	1.2
Nitrate	.4	.4	.4	.4
Dissolved Residue (T. S.)	210	138	355	245
Phenophthalein alkalinity as $CaCO_3$	0	0	0	0
Total hardness as $CaCO_3$	155	102	161	152
Specific conductance Micromhos /CM	350	230	592	408
pH	7.2	7.9	7.9	7.9

---

1. Lake 4 of study

2. Lake 2 of study

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TABLE II — Averages of two tests run each sampling date for dissolved oxygen, free carbon dioxide, alkalinity, pH, total salts and chlorides. The samples were taken one to two inches below the water surface in approximately the same area of the lake. Lubbock County, Texas. Summer, 1962. Lake IV.

DISSOLVED OXYGEN												
DATE	ZONE	P. P. M.	WATER TEMP.	TIME	WATER DEPTH	TOTAL COVER	DATE	FREE CO_2	ALKA-LINITY	pH	TOTAL SALES	CHLORIDES
								PPM	PPM		MHOS	PPM
JULY 16	OW	6.4					JULY 27			7.5		
	WZ	6.6					AUG.3	9.99	57.95	7.2	21.5	12
	SL	5.8					AUG. 9	0.00	50.63	8.1	24.0	4
JULY 27	OW	3.7				0%	AUG. 16	0.00	63.44	7.5	17.0	4
	WZ	3.8					AUG. 23	0.00	71.37	8.1	26.2	2
	SL	1.4				30%	AUG. 30	0.00	86.00	7.1	27.0	
AUG. 3	OW	8.5	82°F	7:28 P								
	WZ	7.5	83°F	7:35 P								
	SL	2.9	85°F	7:25 P								
AUG. 9	OW	6.5	93°F	5:00 P								
	WZ	8.4										
	SL	5.6										
AUG.16	OW	8.0	82°F	2:40 P	28"	0%						
	WZ	12.8	91°F	3:00 P	5"	45%						
	SL	16.3	99°F	2:20 P	1"	25%						
AUG. 23	OW	6.2	78.5°F	11:55 A	28"	0%						
	WZ	7.3	83°F	12:10 P	2"	60%						
	SL	13.5	87°F	12:10 P	5"	20%						
AUG. 30	OW	8.0	98°F	2:55 P	5 1/2"	0%						
	WZ	4.8	89°F	3:10 P	2"	75%						
	SL	7.0	91°F	2:15 P	1"	15%						

DISSOLVED OXYGEN							FREE CO_2	ALKA-LINITY	pH	TOTAL SALTS	CHLO-RIDES
DATE	ZONE	P.P.M.	WATER TEMP	TIME	WATER DEPTH	TOTAL COVER	PPM	PPM		MHOS	PPM
Sept. 6	OW	10.1	73°F	6:35 P	14"	5%					4
	WZ	6.8	72°F	7:00 P	20"	50%					
	SL	3.3	74°F	6:10 P	1"	40%	16.0	70.2	7.6	21	
Sept. 21	OW	9.3	77°F	11:30 A	10"	10%	0.00	67.4		21	
	WZ	4.3	76°F	11:15 A	5"	85%	7.5			28	
	SL	8.2	75°F	10:30 A	1"	45%	0.00	86.4		24	
Oct. 18	SL	3.5	76°F	3:45 P	1"	45%	0.00	67.1	7.4	28	3
Oct. 26	OW	6.4	58°F	10:50 A	10"	0%					
	WZ	5.0	58°F	11:20 A	5"	75%					
	SL	5.7	59°F	10:15 A	1"	65%	0.00	90.3		34	
Nov. 2	OW	8.9	59°F	11:15 A	5"	3%					
	WZ	8.3	58°F	11:20 A	3"	80%					
	SL	10.3	60°F	11:40 A	½"	30%	0.00	108.6		42	

Table II (Contd.).

TABLE III

Averages of two tests run each sampling dates for dissolved oxygen, free carbon dioxide, alkalinity, pH, total salts, and chlorides. The samples were taken one to two inches below the water surface in approximately the same area of the lake. Lubbock County, Texas. Summer, 1962. Lake X.

		DISSOLVED OXYGEN										
DATE	ZONE	P.P.M.	WATER TEMP	TIME	WATER DEPTH	TOTAL COVER	DATE	FREE CO_2 PPM	ALKA-LINITY PPM	pH	TOTAL SALTS MHOS	CHLO-RIDES PPM
JULY 15	OW	5.8	---	---	---	---	JULY 27	---	---	7.3	---	----
	WZ	5.6	---	---	---	---	AUG. 3	89.89	45.75	7.8	19.0	16
	SL	5.5	---	---	---	---	AUG. 10	129.84	44.53	7.0	22.0	4
JULY 27	OW	5.1	---	---	---	20%	AUG. 16	139.82	80.52	8.1	18.0	2
	WZ	1.2	---	----	---	---	AUG. 23	0.00	73.81	7.8	32.0	2
	SL	1.2	---	---	---	95%	AUG. 30					
AUG. 4	OW	5.9	89°F	6:00 P	---	40%						
	WZ	3.9	87°F	5:50 P	---	95%						
	SL	1.3	90°F	6:07 P	---	95%						
AUG. 10	OW	2.8	76°F	9:00 A	---	---						
	WZ	3.7	75 F	8:45 A	---	---						
	SL	3.7	71 F	8:30 A	---	---						
AUG. 16	OW	8.2	87°F	4:45 P	8"	40%						
	WZ	6.2	85°F	5:05 P	4"	90%						
	SL	3.7	80°F	4:30 P	1"	100%						
AUG. 23	OW	5.7	85°F	4:40 P	4"	25%						
	WZ	6.1	80°F	4:30 P	2"	85%						
	SL	6.5	86°F	4:10 P	1"	40%						
AUG. 31												

DISSOLVED OXYGEN							FREE CO_2	ALKA-LINITY	pH	TOTAL SALTS	CHLO-RIDES
DATE	ZONE	P.P.M.	WATER TEMP	TIME	WATER DEPTH	TOTAL COVER	PPM	PPM		MHOS	PPM
Sept. 6	OW	5.3	74°F	4:15 P	5"	45%					6
	WZ	2.5	73°F	4:35 P	4"	98%					
	SL	3.7	71°F	3:45 P	2"	90%	11.0	59.8	7.3	22	
Sept. 29	OW	9.8	77°F	2:30 P	2"	40%	32.4	44.5		25	
	WZ	5.0	76°F	2:50 P	1"	95%	132.3	46.1		23	
	SL	4.7	75°F	2:05 P	½"	90%	72.4	42.4		24	
Oct. 4	LH*	4.9	65°F	11:00 A	4"	40%	92.4	64.4			
	SH**	10.1	68°F	11:23 A	1½"	4%	32.5	71.1			
Oct. 20	OW	13.3	73°F	12:35 P	1"	20%			7.5		3
	WZ	5.0	59°F	12:45 P	3"	95%					
	SL	7.4	60°F	12:05 P	½"	85%	3.5	36.6		27	

*LH= Large Hole sampled on this date that measured one ft. by seven ft. by four inches deep.

**SH= Small Hole sampled on this date that measured ten in. by twenty in. by one and one-half inches deep.

Table III (Contd.).

TABLE IV— Averages of two tests each sampling date for dissolved oxygen, free carbon dioxide, alkalinity, pH, total salts, and chlorides, The samples were taken one to two inches below the water surface in approximately the same area of the lake. Lubbock County Texas. Summer, 1962. Lake V

DISSOLVED OXYGEN												
Date	Zone	P. P. M.	Water Temp	Time	Water Depth	Total Cover	Date	Free CO2	Alka-linity	pH	Total Salts	Chlorides
								PPM	PPM		MHOS	PPM
JULY 23	OW	5.2	---	3:00 P	---	---	AUG. 4	34.96	43.92	7.3	14.0	10
AUG. 4	OW	3.5	89° F	2:05 P	---	---	AUG. 10	69.91	67.71	8.1	19.2	2
	WZ	4.3	94° F	2:20 P	---	---	AUG. 17	49.94	83.57	7.1	26.0	2
	SL	4.7	94° F	1:55 P	---	---	AUG. 23	0.00	115.29	8.1	16.5	14
AUG. 10	OW	7.5	93° F	5:20 P	---	---	AUG. 31	0.00	68.32	7.4	21.0	---
	WZ	5.2	93° F	5:30 P	---	---						
	SL	4:0	93° F	4:40 P	---	---						
AUG. 17	OW	13.4	90° F	5:15 P	10"	2%						
	WZ	4.3	83° F	5:30 P	2"	85%						
	SL	6.5	90° F	4:45 P	3"	40%						
AUG.23	OW	!!.@	88° F	6:47 P	12"	10%						
	WZ	7.0	84° F	7:02 P	6"	60%						
	SL	6.3	83° F	6:15 P	2"	40%						
AUG.31	OW	9.2	84° F	4:35 P	8"	15%						
	WZ	4.2	83° F	4:45 P	7"	65%						
	SL	5.3	82 F	4:15 P	1"	75%						

DISSOLVED OXYGEN							FREE CO_2	ALKA-LINITY	pH	TOTAL SALTS	CHLO-RIDES
DATE	ZONE	P.P.M.	WATER TEMP	TIME	WATER DEPTH	TOTAL COVER	PPM	PPM		MHOS	PPM
Sept. 6	OW	6.1	69°F	11:55 A	10"	0%					4
	WZ	1.8	68°F	12:10 P	3"	75%					
	SL	9.1	70°F	11:30 A	1"	5%	3.0	80.5	7.2	20	
Sept.29	OW	8.3	70°F	11:45 A	5"	0%	0.00	56.7		18	
	WZ	8.7	74°F	12:10 P	3"	65%	42.8	39.4		17	
	SL	10.6	73°F	11:20 P	1"	3%	0.00	57.0		18	
Oct. 4	OW	8.3	66°F	9:50 A	4"	0%	0.00	87.9		28	
	WZ	5.5	64°F	10:10 A	3"	55%	7.7	94.9		32	
	SL	9.0	70°F	9:20 A	1"	1%	0.00	78.4		27	
Oct. 11	OW	7.9	61°F	9:40 A	3"	0%			7.9		
	WZ	5.0	68°F	9:50 A	1"	40%					
	SL	8.2	62°F	9:20 A	1/2"	1%	0.00	107.4		33	2
Oct. 18	OW	8.1	55°F	10:10 A	24"	0%			7.5		
	WZ	6.4	56°F	10:18 A	4"	75%					
	SL	7.7	58°F	9:40 A	1/2"	2%	0.00	54.4		40	4
	RW*	6.7	50°F	10:25 A	1"	10%					
Oct. 25	OW	9.2	51°F	10:10 A	21"	0%			8.0		
	WZ	6.6	52°F	10:20 A	4"	65%					
	SL	10.4	49°F	9:40 A	1/2"	2%	0.00	49.4		16	2
Nov. 1	OW	9.5	53°F	11:43 A	21"	0%					
	WZ	8.4	53°F	11:54 A	4"	65%					
	SL	9.9	57°F	11:20 A	3"	3%	0.00	54.3		22	

*RW= Running Water sampled on this date, the stream was approximately one foot wide and one inch deep at the lowest point.

Table IV (Contd).

DISSOLVED OXYGEN							FREE CO_2	ALKA-LINITY	pH	TOTAL SALTS	CHLO-RIDES
DATE	ZONE	P.P.M.	WATER TEMP	TIME	WATER DEPTH	TOTAL COVER	PPM	PPM		MHOS	PPM
Nov. 9	OW	10.9	58°F	1:55 P	10"	0%					
	WZ	11.3	59°F	2:10 P	6"	16%					
	SL	9.7	65°F	2:35 P	1"	3%	0.00	59.8		24	
Nov. 15	OW	10.2	48°F	11:40 A	10"	0%					
	WZ	10.2	59°F	11:50 A	6"	20%					
	SL	10.1	51°F	11:15 A	¼"	2%	0.00	64.1		25	

Table IV (Contd).

TABLE V—Chemical composition of water from one playa on one day with samples along a larva sampling September 12, 1962. Lake IV.

Stop No.	P. P. M. of D. O.		Water Temp.	Time	Water Depth	Total Cover	P.P.M. of Free CO2		P. P. M of Alk.		pH	Total Salts	
1*	8.4	8.7	82°F	9:50 am	1/2"	5%	0.0	0.0	71.7	68.3	7.6	33	
2*	6.9	6.9	74° F	10:50 am	13"	0%	0.0	0.0	76.9	76.3	7.7	35	
3*	7.1	7.1	74°F	11:10 am	14"	2%	0.0	0.0	61.6	70.1	7.6	28	
4*	9.5	9.5	82°F	3:15 pm	16"	1%	0.0	0.0	55.5	73.2	6.7	17	
5*	9.7	9.9	82° F	3.40pm	15 1/2"	1%	0.0	0.0	69.5	---	6.9	15	
6*	9.6	9.7	83° F	4:00 pm	16"	1%	0.0	0.0	67.1	60.4	---	---	
7*	9.4	9.5	83° F	4:20 pm	15"	8%	0.0	0.0	67.7	66.5	7.0	17	
8*	9.5	9.6	85°F	4:45 pm	13 1/2"	3%	0.0	0.0	64.7	66.5	6.8	21	
13**	9.9	9.7	85° F	5:15 pm	13"	20%	0.0	0.0	65.3	66.5	7.2	17	
18***	9.1	---	82° F	5:45 pm	1"	15%	0.0	0.0	67.1	64.7	7.4	17	
19*A	7.2	7.1	85° F	6:15 pm	3"	1%	0.0	0.0	101.3	98.5	7.4	23	
20*B	2.8	2.5	80° F	6.45 pm	2"	70%	44.9	45.9	92.7	97.6	7.1	33	

*Starting at the shore line samples were taken every thirty feet to the center of the lake

**Thirty feet was skipped between this sample and the previous sample on transect five

***Thirty more feet was skipped and was on the shore line

*A This sample was taken in a hole five feet by nine feet off transect seven.

*B This sample was taken in a hole between transects seven and eight away from the main lake.

APPENDIX VI. Floral and Faunal Checklist

WILDLIFE SURVEY

Class Mammalia
  Order Rodentia
    1. *Peromyscus maniculatus* - white footed deer mouse
    2. *Sigmodon hispidus* - cotton rat
    3. *Cynomys ludovicianus* - black-tail prairie dog
    4
  Order Lagomorpha
    1. *Lepus califonicus*
    2. *Sylvilagus virginina*

The following checklist is preliminary. Grateful acknowledgment is made to Don Krieble, Fish and Wildlife Service, Lubbock, Texas, who kindly identified most of the birds in field observations.

Class Aves
  Order Ciconiiformes
    1. *Aredea herodias* - great blue heron
    2. *Casmerodius albus* - american egret

  Order Anseriformes
    1. *Anas platyrhynchos* - mallard
    2. *Acuta tzitziboa* - pintail
    3. *Anas carolinensis* - green-winged teal
    4. *Anas discoys* - blue-winged teal
    5. *Anas cyanoptera* - cinnamon teal
    6. *Marecea americana* - baldpate
    7. *Spatula clypeata* - shoveller
    8. *Aythva americana* - redhead
    9. *Aythya valisineria* - canvas-back
    10. *Aythya affinis* - lesser scaup
    11. *Glaucionetta clangula* - american golden-eye
    12. *Glaucionetta albeola* - buffle-head
    13. *Mergus merganser* - american merganser

  Order Falconiformes
    1. *Circus syaneus hudsonius* - marsh hawk
    2. *Falco sparverius* - sparrow hawk

  Order Galliformes
    1. *Colinus virginianus* - bobwhite quail
    2. *Callipepla squamata* - bluetop quail

  Order Gruiformes
    1. *Fulica americana* - coot
    2. *Grus canadensis* - sandhill crane

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WILDLIFE SURVEY (continued)

Order Charadriformes
1. Numenius americanus - long-billed curlew
2. Arenaria interpres morinella - ruddy turnstone
3. Limnodromus griseus - dowitcker
4. Catoptrophorus semipalmatus - willet
5. Totanus melanolencus - greater yellow-legs
6. Totanus flavipies - lesser yellow-legs
7. Recurvirostra americana - avocet
8. Ereunetes pusillus - semipalmated sandpiper
9. Charadrius alexandrinus - snowy plover
10. Steganopus tricolor - Wilson's phalarope
11. Charadrius vociferus - killdeer

Order Columbiformes
1. Zenaidura macroura - mourning dove
2. domestic pigeon

Order Caprimulgiformes
1. Chordeiles minor - nighthawk

Order Passeriformes
1. Iridoprocne bicolor - tree swallow
2. Hirundo rustica erythrogaster - barn swallow
3. Eremophila alpestris - horned lark
4. Calamospiza melanocorys - lark bunting
5. Zanthoceph xanthocephalus - yellow-headed blackbird
6. Agelaius phaeniceus - red-wing
7. Sturnella magna - meadowlark
8. Euphagus cyanocephalus - Brewer's blackbird
9. Molothrus ater ater - Eastern cowbird
10. Passer domesticus - English sparrow
11. Mimus polyglottus - mockingbird
12. Tyrannus verticalis - western kingbird
13. Muscivora forticata - scissor-tailed flycatcher

Class Amphibia

Order Caudata
1. Ambystoma tigrinum - tiger salamander

Order Salientia
1. Bufo woodhousii - garden toad
2. Microhyla olivacea - Western narrow-mouthed frog
3. Rana pipiens - leopard frog
4. Pseudacris clarkii - spotted frog

WILDLIFE SURVEY (continued)

5. *Bufo terrestris americanus* - common american toad
6. *Bufo pugnatus* - plains toad
7. *Scaphiopus couchii* - sonoran spadfoot

Class Reptilia

Order Squamata

1. *Holbrookia maculata*
2. *Crotophytus collaris* - collard lizard
3. *Sceloporus undulatus* - rough-scaled lizard
4. *Phrynosoma cornutum* - horned lizard
5. *Cnemidophorus sexlineatus* - six-linned racerunner

Suborder Serpentes

1. *Heterodon nasicus nasicus* - Western hog-nosed snake
2. *Thamnophis marciana* - checkered gartersnake

Order Testudinata

1. *Kinosternon flavescens* - yellow mud turtle

FLORAL CHECK LIST

The following check list is preliminary. Grateful acknowledgment is made to Professor Chester Rowell, Jr. of the Biology Department of Texas Technological College who kindly identified the collected specimens.

Plants of higher forms found on Playa Lakes

1. *Phyla cunefolia* - verbena
2. *Alphanostephus ramosissmus* - lazy daisy
3. *Nama hispidum* - sand-bell
4. *Asclepios latifolia* - milkweed
5. *Helianthus ciliaris* - blueweed
6. *Sophora nuttalliana* - white loco
7. *Coreopsis cardaminefolia* - golden wave
8. *Oenthera laciniata* - Texas buttercup
9. *Zinnia grandiflora* - zinnia
10. *Amaranthus sp.* - green pigweed
11. *Vernonia baldwinii* - ironweed
12. *Nothoscordum bivalve* - crow poison
13. *Solanum rostratum* - Buffalo bur
14. *Cuscuta sp.* - love-vine
15. *Helinium badum* - bitterweed

WILDLIFE SURVEY (continued)

16. Machaeranthera australis - compositae
17. Leucelene ericoides - compositae
18. Solanum elaeagnifolium - Trompillo
19. Sisymbrium irio - Rocket mustard
20. Berlandiera texana - Berlandiera
21. Descuarinia pinnata - pansy mustard
22. Chenopodium album - pigweed
23. Quincula lobata - potato family
24. Eleocharis sp. - spike-rush
25. Echinochloa crus-galli - barnyard grass
26. Heleranthera mexicana - conyza
27. Conyza canadensis - conyza
28. Oenothera laciniata - evening primrose
29. Prionopsis ciliata - compositae
30. Sagittatia longiloba - arrow-head family
31. Euphorbia marginata - spurge
32. Lythrum californicum - purple loosetrife
33. Bahia oppositifolia - compositae
34. Artemisia gnaphaloides - compositae
35. Mimosa binucifera - claw-like
36. Aster subulatus ligulatus - blackweed
37. Polygonum lapthifolium L. - smartweed
38. Rorippa nasturtium aquaticum - water-cress
39. Verbeoina sp.
40. Polygonum ramosissimum - smartweed

APPENDIX VII. Economic Survey Form

ECONOMIC EVALUATIONS OF PLAYA LAKES

Southern High Plains of Texas

Name________________________

Location ________________________

Date________Person Collecting
Information____________________

Research supported by the Texas Agriculture Experiment Station, the Department of Agricultural Economics of Texas Technological College, and the Lubbock-County Health Department

Information for the following questionaire concerning wet weather or playa lakes is desired to complete a study of the values and economic returns of accumulations of surface water in this area. Any information which you may be willing to give will be combined with similar data about other lakes, and from this an attempt will be made to determine the most efficient use of these lakes as a source of water.

A. General

1. Estimated are unavailable for normal cultivation because of lake areas____________
2. Periods during which lake contained water in:
   1961____________months,____________to____________
   1960____________months,____________to____________
   1959____________months,____________to____________
   Remarks:____________________________________
3. Estimated depth of water in lake during high water levels of past years:
   1961________, 1960________,1959 ________,other________
   Remarks____________________________________
4. a. Estimated area surrounding lake which occasionally floods and ruins or damages crops____________acres
   b. How often does such flooding occur?____________________
   c. When did it last occur?________________________
   d. Remarks:____________________________________

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5. a. Estimated area in entire watershed draining into lake ____________
   b. Estimated percentage of this area under irrigation ____________
   c. Number of different farmers in this watershed ____________
   d. Number of wells pumping tailwater into lake ____________
   e. Crops grown in watershed ____________
   f. Remarks: ____________

B. Cultural Practices

1. In what way, if any, has lake been modified from its natural state?
   None_____ Pit_____ Trench_____ Pump sump_____ Recharge well_____ Other_____
   Remarks: ____________

2. Do you plow or attempt to work your lake bed when it is dry? ____________
   a. Have you ever tried to do this? ____________
   b. Remarks: ____________

3. Has lake bed ever produced a crop? ____________
   a. If so, what __________ value __________ when __________
   b. Remarks ____________

4. Cropping practices around lake: Terraces_____ Contour_____ Level benches_____ Pasture_____
   Remarks: ____________

C. Attitudes

1. Has this lake added or detracted from value of your farm? ____________
   How? ____________
   Remarks: ____________

2. Have you considered using your lake in any other way? ____________
   Remarks: ____________

3. Have insects such as mosquitos ever been much of a problem around your lake?
Remarks:

4. In what ways is this lake an asset or liability?
Asset:

Liability:

Remarks:

5. Have you tried any of the following practices around this lake and what is your feeling about each?
______Terraces
______Contour farming
______Level benches
Other

6. What do you feel would have to be done to eliminate water concentration enter entirely from this lake?

Do you think this would pay?

7. Do you have any problems on the use of your lake which might be answered through research?
Remarks:

Would you be willing to cooperate in research on your lake to help answer these problems?
To what extent?
Remarks: